DOCUMENT RESUME

ED 411 643 EC 305 835

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TITLE Increasing the Content Area Learning of Learning Disabled Students: Research Implementation. Final Report.
INSTITUTION Purdue Univ., Lafayette, IN.
SPONS AGENCY Special Education Programs (ED/OSERS), Washington, DC.
PUB DATE 1990-12-31
NOTE 490p.
CONTRACT G008730144
PUB TYPE Reports - Descriptive (141)
EDRS PRICE MF02/PC20 Plus Postage.
DESCRIPTORS *Classroom Techniques; Cues; Junior High Schools; Keywords; *Learning Disabilities; Learning Strategies; *Mnemonics; *Recall (Psychology); *Retention (Psychology)

ABSTRACT

This report describes the outcomes of a 3-year project that investigated the effectiveness of mnemonic instruction of secondary students with learning disabilities. Classroom-based mnemonic instruction was implemented in junior-high school self-contained classrooms. The report first presents theoretical and empirical support for mnemonic instructional techniques. Second, a thorough review of recent research in mnemonic instruction of special populations is provided. Third, a detailed description of the research activities undertaken in this federally funded research program is given. Last is a discussion of the knowledge gained from the research and its implications for the special education of students with learning disabilities and other mild disabilities. Results found that students when instructed mnemonically scored much higher on tests, including recall tests of up to 8 weeks of instruction, than when they were instructed traditionally. Additionally, teachers rated mnemonic instruction as significantly more appropriate for students with learning disabilities. Students also strongly favored mnemonic instruction. Findings also indicate that the students could be taught to generate their own mnemonic strategies when prompted by the teacher during the course of instruction and when trained independently by experimenters. Appendices included the published articles and manuscripts generated by this project. (Contains 78 references.) (Author/CR)

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ED 411 643

FINAL REPORT:

Increasing the Content Area Learning of Learning Disabled Students: Research Implementation*

Grant #G008730144

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December, 1990

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*This report is adapted from T.E. Scruggs & M.A. Mastropieri (1990). The case for mnemonic instruction: From laboratory investigations to classroom applications. Journal of Special Education, 24, 7-32.

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Abstract

This report describes the results of research implementations conducted under grant #GOO8730144, Research Implementation that was funded by the U.S. Department of Education, Special Education Programs from July 1, 1987 through December 31, 1990. First, theoretical and empirical support for mnemonic instructional techniques is presented. Second, a thorough review of recent research in mnemonic instruction of special populations is provided. Third, a detailed description of the research activities undertaken in this funded research program is given. Last is a discussion of the knowledge gained from this research and its implications for the special education of students with learning disabilities and other mild disabilities. Following this article are the published articles and manuscripts generated by this project.

FINAL REPORT:

Increasing the Content Area Learning of Learning Disabled Students: Research Implementation

Grant #GOO8730144

Over the past decade, the present project co-directors have completed a number of experimental investigations concerning mnemonic (memory-enhancing) strategy use in exceptional populations. These investigations have taken us from initial explorations of spontaneous strategy use of gifted adolescents to grant-supported, broad implementation of a variety of powerful mnemonic strategies which dramatically enhanced the classroom success of learning disabled (LD) and mildly mentally handicapped (MiMH) students. These findings have also been supported by other independent researchers, primarily in dissertation research. Although we feel that there is an important need for further research on mnemonic strategy use in exceptional populations, we also feel that we have reached a point in our research, particularly after the last three years of federally-supported implementation studies, in which we can offer wholehearted support for the use of mnemonic techniques in the teaching of mildly handicapped students.

This report, then, is intended to describe the findings from a three-year research implementation grant from the perspective of our decade-long study of mnemonic strategies, and to provide a rationale for our choice of learning tasks, designs, and implementation formats. We will argue that research designs, materials, and procedures used at the beginning of a line of research will necessarily differ from designs, materials, and procedures used at later stages in the research, and we will offer our justification for these differences. We will also attempt to support our own position that research intended to influence instructional practice should be designed as a long series of individual but interdependent investigations, rather than one or two "major" studies which attempt to answer most or all relevant research questions at once. Finally, we will describe the findings of independent researchers who have also explored mnemonic strategies, and discuss the necessary role of independent replication and extension.

Foundations of Mnemonic Instruction

Meaningfulness, Concreteness, and Elaboration

Theoretical and empirical foundations for the use of mnemonic strategies with exceptional populations have been provided from the experimental learning literature, as well as literature documenting learning deficiencies of exceptional populations. For many years, researchers (e.g., Underwood & Shultz, 1960) have reported that learning is strongly influenced by meaningfulness. That is, the more meaningful information is, the more easily it is acquired. (Underwood and Schultz, 1960, described familiarity as a "natural" synonym of meaningfulness). It has also been reported (e.g., by Paivio, 1971) that concreteness plays an important role in learning success, and that semantic elaboration of stimulus and response information (e.g., Rohwer, Raines, Eoff, & Wagner, 1977) is known to facilitate associative recall. Taken together, these theories (as well as common sense) suggest that concrete, meaningful (or familiar), elaborated information will be more easily learned than, for example, nonmeaningful (or unfamiliar), abstract, and unelaborated information. Unfortunately, in the reality of school learning, many students are likely to find to-be-learned information more representative of the latter characterizations.

Individual Differences

How do concreteness, meaningfulness, and elaboration interact with individual differences? In a series of investigations involving highly able ("gifted") as well as more typical learners, Scruggs (1982), Scruggs and Cohn (1983), and Scruggs and Mastropieri (1985) reported that, when confronted with pairs of unfamiliar paralogs ("nonsense" words) to learn, highly able learners were able to "reconstruct" these unfamiliar elements into more meaningful units, and effectively elaborate them with their associates, to a greater extent than were more typical learners of their own age. For example, given the paralog pair BODKIN-NOSTAW to learn, typical junior high school students were likely to report, "I said the words over and over to myself." Their gifted counterparts, on the other hand, were more likely to report effective reconstructions and elaborations, such as, I thought, "The BODy has a NOSe." Such a reconstruction transforms essentially nonsense words into concrete, meaningful representations, and effectively elaborates stimulus with response information to facilitate later retrieval. When asked for the associate of BODKIN, then, the learner can think of the reconstructed BODy, and easily remember the meaningfully-elaborated response. When students reported using such strategies, their probability of remembering the word pair was much greater than when they reported lower-level strategies, such as rehearsal, which did not take meaningfulness, concreteness or elaboration into account.

Supported by the experimental learning literature, then, we saw that independent reconstructive and elaborative strategy use predicted learning, to a similar degree, in both average and high-ability groups. What differentiated the groups was the relative ability to spontaneously generate such strategies. The gifted students scored higher because of their ability to create these strategies more frequently than did their more typical age peers. These investigations did not demonstrate that such strategies could be provided to learners to increase their learning, or that learners could be taught to generate independently such strategies. However, they did suggest that independent strategy use, along the dimensions of meaningfulness, concreteness, and elaboration, were strongly predictive of learning success (more so than "ability" characterizations), and would be fruitful avenues for future research. In addition, similar research previously conducted with mentally retarded learners (see Taylor & Turnure, 1979, for a review), had suggested that similar deficiencies in strategy use differentiated MiMH from more typical learners, and that provision of appropriate elaborations facilitated their performance on these experimental learning tasks.

Strategy deficits. More recently, researchers investigating cognitive strategies used by learning disabled students have reported deficiencies in spontaneous generation of effective memory strategies. Researchers such as Ceci (e.g., 1985; Baker, Ceci, & Herrmann, 1987) have suggested that the field could more profitably investigate the type of learning strategies which could be taught to LD students, rather than, for example, more global investigations of general "processing" deficits:

> ...Instead of advocating intervention plans that are directed at remediating alleged cerebral insult or dysfunction, a more profitable approach to children with semantic processing difficulties...is to train purposive information-processing strategies like elaborative encoding, chunking, anticipation, type 2 rehearsal, and so on (Ceci, 1985, p. 219).

It had also become clear that training designed to remediate such hypothesized processing deficits as perceptual-motor, modality, or psycholinguistic abilities, had failed (Kavale &

Forness, 1985), and that it may be most profitable to turn research attention to the direct training of the cognitive processes used in learning and remembering specific components of school-relevant information. In addition to a stronger theoretical grounding, strategy-deficit theories had more specific implications for teaching than did more general "processing" theories.

Some earlier elaboration research had been conducted with exceptional populations, but, in spite of being widely cited, failed to produce any significant impact on educational practice. Jensen and Rowher (1963) trained MiMH adults to learn pairs of concrete, meaningful information (e.g., FROG-POCKET, COW-BALL) by creating sentences that effectively elaborated the two terms (e.g., "A frog jumped in the pocket," or "The cow kicked the ball"). Trained subjects learned many more word pairs in the same amount of time than untrained subjects; however, the instructional implications of such research were uncertain due to the lack of content validity of the experimental materials: exactly what school learning tasks could such experimental tasks be said to represent? The history of verbal elaboration research in the 1960s and 1970s (see Taylor & Turnure, 1979) suggests that researchers at that time were primarily interested in addressing more basic research questions involving optimizing performance or inducing strategy transfer on experimental lists, rather than exploring school-relevant applications of these findings.

Possibly due to the lack of such task relevance, models of special education instruction derived at least in part from behavioral, rehearsal-based theories (Thorndike, 1931), began to replace process training instruction (Becker, Engelmann, Carnine, & Maggs, 1982). We have argued that rehearsal models, by making use of extensive repetitions, do facilitate learning in the long run by promoting a kind of familiarity; however, instructional models that effectively link new, unfamiliar information to a previously-established knowledge base of concrete, meaningful information are more likely to result in rapid, efficient acquisition of school-relevant content.

Initial Laboratory Investigations

Based upon previous research with normal and exceptional learners, it seemed likely that strategy use, either externally provided or spontaneously generated, would be more likely to positively influence learning than would more global "process" interventions, such as perceptual motor training, or behaviorally-oriented interventions which rely upon rehearsal and externally-provided reinforcement. But what strategic intervention could deal with the previously reported difficulties with task relevance? It appeared that reconstructive mnemonic strategies such as the keyword and pegword methods held great promise.

The keyword method was used thousands of years ago by the Ancient Greeks (Yates, 1965), and had been more recently described in popular memory-improvement books (e.g., Lorayne & Lucas, 1974); however, it was first investigated scientifically by Atkinson (1975), in the learning of foreign vocabulary words. In learning that the Spanish word carta means "letter", for example, the learner is first shown (or prompted to generate) a "keyword" for carta. Since carta is semantically nonmeaningful to a novice learner, the only dimension for meaningful reconstruction is acoustic. In other words, at this point the only thing the learner knows about "carta" is its sound. In this case, "cart" is a good keyword for carta, because it is acoustically similar to the target word, and is concrete, and therefore easily pictured. An elaborative picture, then, could show a letter (definition of carta) in a grocery cart (keyword for carta). What is then elaborated, then, is not the stimulus and the response, but a concrete, meaningful proxy acoustically tied to the stimulus, carta, effectively elaborated (shown interacting) with the response, a postal letter (for more examples, see Mastropieri, 1988).

Similarly, the pegword strategy (Bower, 1970; Miller, Galanter, & Pribham, 1960) employs acoustic rhyming reconstructions for numbers (one is bun, two is shoe, three is tree, etc.) which are then elaborated with corresponding numbered or ordered information. Lebrato and Ellis (1974) employed these strategies with a sample of mentally retarded learners, and concluded that the strategy had been very effective for facilitating recall of number-word pairs. They concluded (pp. 712-713):

> [I]magery mnemonics may be a powerful tool in increasing learning and retention of educational materials, many of which must be learned in a rote fashion. In view of the poverty of truly _special_ training and educational methods for retarded persons, this method bears careful and intensive study.

However, similar to the Jensen and Rohwer (1963) investigation, the experimental materials used (e.g., 1-car, 2-flag, 3-clock) provided an effective test of the strategy, but failed to demonstrate educational relevance. However, we considered keyword and pegword strategies potentially very important because the reconstructive component could help transform unfamiliar school-relevant content into familiar, concrete proxies, while the elaboration component could help assure a strong association between known and unknown information. We therefore began a series of investigations directed toward evaluating school-relevant applications of these strategies with exceptional populations.

Design Considerations

In our initial investigations, we were concerned with determining whether school-relevant mnemonic strategies could _ever_ be effective with exceptional learners. At this initial stage of a program of research, it is important that the research design be as tightly controlled as possible, so that any possible benefit of the particular teaching technique might not be overlooked. In order not to make a Type II error, then (i.e., that tangible differences due to treatment are not observed), it is important to do everything possible to maximize treatment effectiveness. These manipulations could include the following:

1. One-to-one teaching and testing situations, using trained experimenters. Such interventions allow for the least possible experimental error from such extraneous variables as attention, inappropriate behavior, peer interaction, or less-than-optimal implementation. Additionally, individual implementations allow for completely random assignment to treatment conditions, and avoid "independence" concerns which arise when treatments are administered in groups.
2. Brief, intensive experimental sessions. Short implementation periods reduce the possibility of experimental error due to interference, fatigue, or declining attention.
3. Experimental materials which test only the effectiveness of the strategies in question, and which are thought to be highly unfamiliar to learners. Materials which are likely to be familiar or even partially familiar can introduce experimental error due to prior knowledge. That is, the subject responds correctly not because of the effectiveness of the teaching strategy, but because he or she already

knows the information being "taught." Random assignment to treatment groups can reduce concerns of differential effects of prior knowledge; however, if subjects already know, for example, 20% of the experimental content, that previously learned information will not discriminate among treatments, and will reduce the experimental power of the design.

4. Treatments only one session in length. Treatments which last longer than one session are vulnerable to subject attrition, which can seriously threaten the validity of any findings. Longer treatments are also are vulnerable to any information or attitudes the student may acquire between treatment sessions. For instance, a student may become interested in the information being taught and read about it at home, between sessions. It is also possible that students taught certain information over time could discuss this information among themselves between sessions. At best, this could invalidate assumptions of "independence," and at worst, could represent across-treatment contamination (e.g., if students receiving an experimental treatment explain this treatment to control group students). Any of these possibilities could seriously compromise conclusions of a particular investigation. On the other hand, one-session treatments afford no such possibilities for validity threats, especially if students are monitored while the treatment is being conducted, so that it is assured that

students who have just received the experimental treatment do not have the opportunity to interact with students who have not had the treatment.

5. It is also helpful, at this early stage of a research program, to employ only a small number of treatment conditions, for example, just two or three treatments. Such a small number of treatment conditions allows for greater statistical power on necessary pairwise comparisons. Although limiting the number of treatment conditions also limits the number of research questions that can be addressed, additional experiments can be planned to address additional questions.

Task Considerations

We employed designs containing the abovementioned features in conducting our initial mnemonic investigations. One of our first experimental tasks was learning the hardness levels of North American minerals, according to Moh's scale. The mineral hardness scale is ordinal, in which a higher number denotes a harder mineral. For instance, any mineral with hardness level six is harder than any mineral with hardness level five. The scale ranges from one to ten, with diamond, the hardest mineral, representing the only instance of hardness level ten. We chose the learning of mineral hardness levels for several reasons. First, they were, we felt, virtually certain to be unfamiliar to our targeted populations of junior-high-school-aged learning disabled and mildly mentally handicapped students. Second, they afforded an excellent test of the utility of both keyword and pegword strategies, since learning mineral hardness levels would involve learning both a keyword for the mineral name and a pegword for the associated hardness number. Third, although it is difficult to assert that learning and remembering mineral hardness levels is a "typical" school learning task (it was, however, among the objectives of the district we worked in), it did represent a significant advance toward classroom-relevant materials from the earlier experimental associates, such as FROG-POCKET or 2-LADDER.

Research on Mineral Hardness Levels

In an initial investigation (Mastropieri, 1983, reported in Mastropieri, Scruggs, & Levin, 1985b), LD students were assigned at random to one of three conditions and taught individually mineral hardness levels via either mnemonic condition, a rehearsal-based picture control, or a free study condition. Mnemonic condition students were taught keywords for the mineral names and pegwords for the numbers one through ten. During the same time, rehearsal-based and free study condition students received an equivalent amount of time interacting with the experimenter, discussing background information on minerals. During the instructional period, mnemonic and rehearsal-based condition students were shown pictures and given instruction appropriate to each condition at a pace of 30 seconds per mineral. In the mnemonic condition, for example, students were shown a picture of a _horn_ with a bee _hive_ in it, and were told,

> Hornblende is number _five_ on the hardness scale. The keyword for hornblende is _horn_ and the pegword for five is _hive_. Remember this picture of a _horn_ with a _hive_ in it. When I ask you about hornblende, first think of the keyword, horn, think back to the picture with the horn in it, remember that there is a hive in the horn, and give me the correct answer, 'five.' What is the hardness level of hornblende? [provide feedback]. What do you do when I ask you about hornblende? [provide feedback as needed].

In the rehearsal-based condition, students were shown color photographs of each target mineral for the same amount of time (30 seconds) as in the mnemonic condition, while the experimenter said, for example, "Hornblende is number _five_ on the hardness scale. What number is hornblende on the hardness scale? Good, hornblende is five [provide feedback as needed]." This condition provided for a direct comparison between mnemonic-based and rehearsal-based instruction, with rate of presentation of new content held constant. In the free study condition, students were provided with a variety of study materials and told to use whatever method they felt was best for studying the information. This condition provided, in addition to an additional control condition, a means of evaluating the rehearsal-based condition _per se_. Since this was a very early test of the potential efficacy of keyword-pegword strategies, we felt that the purely random assignment, individual presentations, brief, intensive treatments, and single experimental sessions would contribute to maximizing experimental power.

The results of this experiment indicated that students instructed mnemonically reliably outperformed students in the other two conditions, whose performance did not statistically differ. Not only was the overall result "statistically significant," it was seen that the differences between mnemonic and the other two conditions were very substantial: an average of 79.0% correct in the mnemonic condition, versus an average of 27.9% correct in the other conditions. Interestingly, the two comparison conditions did not differ significantly from each other, underlining the poverty of rehearsal-only methods when content is very unfamiliar. Finally, a 24-hour "surprise" delayed recall test reported by Mastropieri (1983) revealed a statistical interaction, indicating the students in the comparison conditions soon forgot what little they had learned, while mnemonically-instructed students actually remembered slightly more information 24 hours later.

This finding of mnemonic superiority was replicated on a small sample of mildly mentally handicapped (MiMH) students (Mastropieri, Scruggs, & Levin, 1986, Exp. 2). Because of the small number of students available for the investigation (N = 8), we used a within-subjects crossover design, in which each student learned eight minerals via mnemonic instruction, and eight additional minerals via rehearsal. Treatment order and target information were counterbalanced, to ensure that between-condition differences in treatment order or relative information difficulty could not differentially influence outcomes.

The results of these investigations provided important initial information regarding the potential of mnemonic instruction of mildly handicapped students. Nevertheless, many important questions remained to be addressed. The use of individual experimenter-led presentations, single sessions, and experimental lists achieved important statistical power, but left untested questions of group, teacher-led instruction with actual school curricula. However, before we initiated such large-scale implementations, we elected to replicate our findings, and further test the potential of mnemonic instruction for teaching different types of information.

Multiple Attributes

Designing the experimental condition. Upon examining the results of the Mastropieri, Scruggs, and Levin (1985b) investigation, we began to wonder how much information could be incorporated within a single mnemonic picture. With the incorporation of different types of information, different mnemonic systems would be necessary, and the information-processing load on our target populations would necessarily be much greater. For example, what if, instead of teaching a single mineral and associated hardness level, we were to teach hardness levels, colors, and common uses associated with specific mineral names? Could all such information be incorporated mnemonically in a single picture, or would disabled learners be able to absorb only a single mnemonically elaborated fact? To address these questions, we developed a set of eight mnemonic pictures representing these three attributes of each of eight common minerals. We retained the pegword for the hardness level, but also integrated within the picture the color of the mineral, by coloring the pictured keyword, and provided an interactive mimetic (representative) picture of the common use. Thus, to show that crocoite was two on the hardness scale, orange in color, and used by collectors for displays, we constructed a picture of orange (color) crocodiles (keyword for crocoite), wearing shoes (pegword for hardness level two) in a display case (common use). We planned for 30 seconds of presentation time per picture, as in the Mastropieri, Scruggs and Levin (1985b) investigation, to test whether we could present three items of information in the same rate of presentation in which we had previously taught only one item of information.

Designing control conditions. We were also concerned about our design of comparison conditions. Frequently overlooked is the fact that the conclusions of research investigations have as much to do with the control or comparison conditions as they do to the researcher's treatment of choice. Lovitt (1988, p. 483) has aptly cautioned against the use of comparison conditions that are insufficiently described or do not represent state-of-the-art treatments. Borkowski and Buchel (1983) have argued that, when evaluating specific instructional strategies, the most effective control condition should represent the best available treatment known at the time. The outcomes of instructional research are of little value if they merely document that a specific treatment is reliably better than no treatment at all, or a mediocre and poorly operationalized alternative treatment.

In light of our concerns about alternative treatments, we aimed for treatments which would also replicate and extend our comparison conditions. Specifically, we were concerned with our previous rehearsal-based condition, which controlled for the overall pace of content presentation, but may not have been the most effective use of rehearsal-based instruction, since it did not include faster-paced presentations and cumulative review of previously-rehearsed information. We were also concerned that rehearsal-based conditions may be more effective if less content were presented at one time. That is, more total information may be learned if less potentially confusing content were introduced at one sitting. Therefore, in addition to a free study condition, we included two additional rehearsal-based conditions. Both included fast-paced instruction, immediate feedback, and cumulative review throughout the lesson; however, in one condition, we attempted to teach three attributes each of only four rather than eight minerals, in the same amount of time. We argued that, conceivably, 100% of the information could be learned about four minerals, whereas perhaps only 40% of the information might be learned about eight minerals. If this happened, it would mean that we had inhibited the performance of students in the first rehearsal-based condition by introducing too much content, and that students taught less could actually learn more. In addition to the two (fast-paced and slower-paced) rehearsal-based conditions, we also added a free study condition, as in the previous experiment, as a control for the rehearsal-based methods per se.

In the previous investigation (Mastropieri, Scruggs, & Levin, 1985b), we had replaced mnemonic-condition keyword and pegword training, in the comparison conditions, with interaction with the experimenter on the general topic of minerals. At that time, we did not substitute the keyword-instruction time for additional content instruction in comparison conditions because, we felt, mnemonic students were receiving strategy-relevant information only, and not direct training of minerals and associated hardness levels. However, we decided for this, and future experiments, to replace time spent in keyword and pegword training, in the mnemonic condition, with additional direct instructional time on the target content in the control condition. Therefore, for the remaining studies we conducted, control condition students actually received more instructional time (up to 40% more) for target information than did mnemonic condition students, who needed additional time to study keyword and pegword reconstructions before being presented with the actual content. This manipulation, we felt, afforded the most rigorous possible test of mnemonic instruction, and more accurately met the description of "best available treatment" for the control condition.

Results. In this experiment (Scruggs, Mastropieri, Levin, & Gaffney, 1985), as well as the subsequent experiments, mnemonic instruction resulted in substantially (and significantly) higher levels of learning than did control conditions, and even resulted in a higher percentage of content learned than when attributes of only four (rather than eight) minerals were taught! In addition, analysis of each type of attribute (hardness, color, use) revealed that LD students were able to retrieve (presumably, through imagery) colors as well as representational pictures, and these colors could be interpreted meaningfully. Perhaps even more surprisingly, we found that rehearsal-based comparison conditions resulted in levels of recall that were no higher than free study conditions. This was a startling surprise to us because, we felt, experimenter-led, fast-paced instruction with immediate feedback and cumulative review was virtually certain to outperform "free study" conditions. (In fact, in the first experiment, one of us predicted rehearsal would prove more effective than mnemonic instruction).

In a follow-up experiment (Mastropieri, Scruggs, McLoone, & Levin, 1985), we decided to teach, not specific attributes of minerals (hardness = 2; color = orange; use = displays), but dichotomized attributes of these minerals (soft vs. hard; light vs. dark color; home vs. factory use). The reason we chose this task was that we wanted to know whether we could portray symbolically (rather than with representative pictures) mineral attributes. In this case we used, to portray hardness, an old man (hard) or a baby (soft); to portray color, blackened-in keyword (dark) or not blackened-in keyword (light); to portray use, a home scene (home use) or a factory scene (industrial use). For example, for crocoite, we employed a picture of a blackened-in (dark color) crocodile (keyword for crocoite) playing with a baby (soft mineral) in a home scene (home use). The questions we wished to test, then were: (a) could learning disabled students make use of (i.e., correctly interpret) symbolized mineral attributes, rather than actual representational pictures?, and (b) would LD students become confused with multiple instances of the same symbolized attribute (e.g, several "baby" pictures, or several factory scenes)?

In order to investigate these questions, we used a design similar to the ones used previously, with three conditions: mnemonic, rehearsal-based (with fast-paced questioning, feedback, and cumulative review), and free study. Not only did results parallel the findings of previous investigations, in that mnemonically instructed students substantially outperformed students in rehearsal-based and free study conditions, we also found that free study students performed statistically higher than students instructed with rehearsal-based methods! Our interpretation of this finding was that LD students, allowed to pace themselves, may have been better able to tie the information in some way to their prior knowledge system. Students in the experimenter-led rehearsal-based condition, on the other hand, may have been inhibited from elaborating the information, or in any way making the information more meaningful for themselves. In defense of rehearsal-based instruction, however, it should be acknowledged that our free study condition students were individually treated and closely monitored, as in the other conditions. This treatment should not in any way be interpreted as representative of the undesirable but all-too-prevalent condition found in resource rooms, in which students are given an "individual" folder of worksheets and asked to complete them in situations in which they are not closely monitored. It is also true, we feel, that rehearsal-based methods may be more effective when the information is more familiar to learners. These, however, are empirical questions, which await empirical investigation.

"Visual-spatial displays." Two additional research studies, at least in part, followed from comments offered from anonymous reviewers of the research reports. From a anonymous reviewer's comments on a manuscript submitted for publication, we received the idea that a "visual-spatial display," of the type proposed by Engelmann and Carnine (1982), and in which relationships among individual facts are highlighted spatially, would provide a superior control condition. In response to this concern, we conducted a two-experiment investigation in which "visual-spatial displays" replaced the rehearsal-based condition (Scruggs, Mastropieri, Levin, McLoone, Gaffney, & Prater, 1985). In the second experiment, we also examined potential age constraints of mnemonic instruction by employing elementary aged LD students. In both experiments, mnemonic condition subjects substantially outperformed comparison condition students, including those in the "visual-spatial display" conditions. In these experiments, the visual-spatial display conditions were neither superior nor inferior to free study conditions in promoting learning.

In response to a reviewer's comments on this manuscript, that cells we used in the visual-spatial display conditions should have contained pictures of the phenomena (minerals) being studied, we, as part of a larger investigation described later, created a visual-spatial display condition in which the cells did contain pictures of the content elements (dinosaurs). Again, mnemonic condition students far outperformed students using visual spatial displays (Veit, Scruggs, & Mastropieri, 1986). We concluded that such spatial organizing strategies were not effective for facilitating the acquisition of unfamiliar content;

however, it is possible that such spatial organization is potentially valuable in other contexts, for example when relationships among previously learned concepts are being taught. Again, such questions are, of course, empirical.

Group Implementations

The results of the investigations described above suggested that mnemonic instruction could result in impressive learning gains, as compared with several comparison conditions. On the tasks we had employed, mnemonic instruction seemed to be very effective, at least when treatment was implemented individually in single treatment sessions. A question which could be logically derived from these results was whether mnemonic instruction would be seen to be similarly effective when students were taught in small groups and more than one mnemonic lesson was employed.

Minerals

We initially addressed these questions in two experiments. In one experiment, Mastropieri, Scruggs, and Levin (1986, Exp. 1) taught hardness levels of minerals to 56 learning disabled secondary-age students in 12 instructional groups. Since groups, rather than individuals, were assigned at random to one of two treatment conditions, the mean group score, rather than the individual subject score, constituted the "unit of analysis" for the experiment (Hopkins, 1982). The use of the group score also helped maintain the assumption of independence of observations, a necessary requisite for statistical analysis. That is, in a single experimental session, any disruption or irregularity which may occur could be expected to impact upon all subjects in the group, rather than one individual subject. The use of a group mean rather than individual scores, therefore, helped assure independence of the data. Concerns for the sharply reduced number of observations (from 56 down to 12) are mitigated to a certain by our concomitant reduction in experimental groups (from three to two) as well as the virtual certainty that group mean scores will exhibit far less within-condition variability than independent subject scores, due to the fact that individual "outliers" will be absorbed within each instructional group mean. This decreased variability also increased statistical precision and compensated to a large extent to the reduction in the number of observations (for another alternative, the use of subjects as a nested factor, within instructional groups, see Hopkins, 1982). In this case, analysis of the data indicated that mnemonic instruction had resulted in far greater recall than had experimenter-led rehearsal with fast pace, choral responding, immediate feedback, and cumulative review. Although the experimental task and the single instructional session had not changed, the use of groups for instruction provided an important extension that allowed us to design more applied research studies.

Dinosaurs

Veit, Scruggs, and Mastropieri (1986) extended this research by employing, in addition to small group instruction, three separate lessons taught over three days. In this case, we designed three separate and independent lessons on prehistoric reptiles which were taught over three days of instruction. One lesson was concerned with the meanings of dinosaur names, another addressed attributes of dinosaurs (eating habits, geologic period, and an attribute particular to each dinosaur), and another lesson taught a list of hypothesized reasons for dinosaur extinction. The order of these lessons was counterbalanced (i.e., an equal number of students received each lesson in a different order) so that the test scores for each lesson could be compared without concern for any differential "practice" effects. We also wished to combine, for each condition, scores across the first, second, and third day of instruction to determine whether, accounting for possible lesson difficulty effects, there was any tangible change in performance over time. It could be argued, for example, that mnemonically-instructed students could begin to "catch on" after a day or two of mnemonic instruction, and therefore begin to exhibit greater performance gains. On the other hand, it was possible that effects would begin to diminish over time, as students became confused by the presentation of too many mnemonic elaborations.

In this case, as in the previously described investigation, we assigned at random 24 instructional groups of LD students to mnemonic and control conditions. For the vocabulary lesson, the mnemonic condition students were taught parts of dinosaur names (e.g., ptero- = "winged"; saur = "lizard") using the keyword method; control condition students were taught using drill-and-practice procedures, as in the group-implemented "minerals" study. After learning the word parts, students were tested on their ability to comprehend these word parts in novel (for the learners) combinations (e.g., ptero/saur = "winged lizard"). For the attribute lesson, mnemonic condition students were taught using procedures similar to those of the "mineral attribute" studies, while the control condition students used a "visual spatial display", described above. Additionally, in the mnemonic condition we tested whether color could be used symbolically, to represent meat-eater (red) or plant-eater (green), as well as our previous literal use of color. For the extinction lesson, we used a pegword-only strategy to teach possible reasons offered for dinosaur extinction in order of plausibility. For example, for reason number four, that small mammals may have destroyed and eaten dinosaur eggs, we showed a picture of small mammals breaking and eating dinosaur eggs on a door (pegword for four). Students in the control condition were shown a similar picture (without the door and accompanying strategy information) and given drill-and-practice, similar to the vocabulary lesson. After each day, students were given a test of their immediate recall, while on the fourth day, all students were given a cumulative recall test of all information covered.

Results. Results indicated that students instructed mnemonically substantially outperformed control condition students on all daily measures, as well on the delayed recall measure. They also showed no overall decrease (or increase) in learning over time. In addition, in the vocabulary lesson, mnemonically instructed students were more able to apply learned information to novel contexts, in this case, the translation of novel dinosaur names from previously learned word parts. In addition to replicating the effects of the group administered treatment, then, this investigation pursued two commonly raised concerns regarding mnemonic instruction: (a) Is mnemonically learned information comprehensible?, and (b) Can students be instructed mnemonically over several days without becoming confused? The Veit, Scruggs, and Mastropieri (1986) investigation provided positive preliminary support for both these questions.

Limitations. Although this investigation maintained most of the experimental rigor of the previous investigations, it still did not model actual classroom conditions of instruction. First, the materials were chosen by researchers interested in validating certain types of mnemonic systems, rather than by curriculum specialists interested in the content to be conveyed. Second, we assured independence of content so that we could counterbalance presentation order to more effectively evaluate the cumulative effect of mnemonic instruction, without any potential interference from relative lesson difficulty. This means that no content overlapped, even to the extent that no specific dinosaur mentioned in one lesson would be mentioned in any other lesson. Such non-overlapping content, while serving an experimental purpose, is unlikely to occur in any school situation. Additionally, all presentations were scripted and timed exactly for pace of instruction, a condition unlikely to be met in real school situations. Finally, the lessons were delivered by experimenters, rather than regularly-assigned teachers. Nevertheless, the Veit, Scruggs, and Mastropieri (1986) investigation provided the most "ecologically valid" information to date, and provided important information for us to use in designing and implementing future investigations which would take into account actual classroom conditions.

Vocabulary Extensions

Training

Concurrent with the investigations studying content acquisition, we conducted a series of experiments involving vocabulary acquisition of mildly handicapped learners. In these experiments, in which students again were randomly assigned, and individually taught in single instructional sessions, we investigated several issues of relevance to mnemonic instruction. In an initial vocabulary investigation, Scruggs, Mastropieri, and Levin (1985) taught concrete vocabulary words to 20 MiMH students. Because of the relatively small sample size, we used a crossover design, in which each student was taught ten vocabulary words mnemonically, and ten vocabulary words via rehearsal-based instruction. We developed both mnemonic and rehearsal-based materials for all 20 words, however, and alternated sets of materials so that the actual information taught did not vary as a function of condition, and relative word list difficulty could not be a factor in the outcome. Likewise, we alternated treatment orders, so that half of the students received mnemonic instruction first, while the other half received rehearsal-based instruction first. This was done to eliminate concerns that the first (or second) presentation would result in differential performance, regardless of condition.

We also employed, for this investigation, low-frequency vocabulary words from a scrabble dictionary, to eliminate prior knowledge concerns (e.g., bugsha = money; dogbane = tropical plant; peavey = hook). We also selected words which easily lent themselves to keyword reconstructions (bugsha = bug; dogbane = dog; peavey = pea), as we intended this to be a test of the keyword method under ideal conditions. We found, in fact, that under these conditions, students recalled far more vocabulary definitions when instructed mnemonically than when experimenter-led rehearsal was used.

Independent Strategy Generation

In another vocabulary investigation, (Mastropieri, Scruggs, Levin, Gaffney, & McLoone, 1985) we examined, in Experiment 1, whether LD students could be effectively taught vocabulary (the same materials as in the previously described investigation) via the keyword method, and, in Experiment 2, whether another sample of LD students could effectively generate their own mnemonic images, given verbal descriptions of vocabulary words, keywords, and definitions. Experimenter-led rehearsal served as the control condition in both experiments. Results indicated that the keyword method was a very effective treatment for initial vocabulary acquisition, and that LD students could, given keywords and definitions, generate their own interactive images, to the extent that they still significantly outperformed their control counterparts, but not by as wide a margin as when they were provided with interactive mnemonic pictures. This finding provided promise that students, under some circumstances, could learn to generate their own complete mnemonic strategies.

We tested this hypothesis in a study by McLoone, Scruggs, Mastropieri, and Zucker (1986), in which students were directly taught a list of English or Italian vocabulary words, and afterwards trained to create their own keywords and interactive images on the opposite list (we counterbalanced English and Italian words across learning and transfer tasks so the two tasks would be of similar difficulty). Again, we found that the superior effect of keyword instruction was manifested even when students were trained to create their own mnemonic keywords and interactive images. We were, however, reluctant to assert that students could easily transfer keyword-type mnemonic strategies, in that the task we employed was experimental, and the ability of LD students to transfer this method in actual classroom situations was, to this point, unstudied.

Concrete vs. Abstract Words

In a third vocabulary study (Mastropieri, Scruggs, & Fulk, 1990), we addressed three additional research questions: (a) could LD students benefit from keyword vocabulary instruction when vocabulary were not selected for keyword "obviousness?"; (b) could LD students learn abstract as well as concrete vocabulary with the keyword method?; and (c) does mnemonic instruction inhibit comprehension in any way? Impetus for this investigation came from a study by Johnson, Adams, and Bruning (1985), who provided evidence that college undergraduates studying "difficult" vocabulary words remembered mnemonically-instructed concrete vocabulary, but did not recall mnemonically-instructed abstract vocabulary, any better than students had under free study conditions. We decided to test their conclusion, that the keyword method was ineffective for difficult abstract vocabulary words, with a sample of learning disabled students. In this investigation, we employed a mnemonic condition, and a rehearsal-based control condition. We adapted the words of Johnson et al. (1985) with our own mnemonic and control pictures. To test whether our students would also comprehend the information, we devised a comprehension task, in which students were required to identify the target word when used in a context separate from that in which it was taught. The vocabulary words used by Johnson et al. (1985) were difficult (e.g., catafalque, saprophytic, intercalate), and had not been selected for keyword obviousness. We felt certain that, if we could teach these words mnemonically to a junior-high age LD students, we could teach any virtually any vocabulary words to similar students.

Again, the results supported the effectiveness of mnemonic instruction. Not only did the mnemonically-instructed students outperform the rehearsal-condition students on recall of both abstract and concrete information, they also exhibited a substantial performance advantage on the comprehension task. The results of this investigation supported the notion that mnemonic instruction is effective for more ecologically-valid (less contrived) content, and facilitates, rather than diminishes, comprehension. Results of this investigation, furthermore, were particularly helpful in adaptation of specific curricular materials required for the grant-supported research implementation projects which followed.

Prose Adaptations

Prior to large-scale implementation of mnemonic instruction, which would involve workbooks and other classroom materials, we felt that we should evaluate the ability of LD students to benefit independently from mnemonic illustrations and strategy information imbedded within textual material. In other words, would the previous effects of mnemonic instruction of lists of vocabulary and factual information still be realized when this information was embedded within "textbooks" which students read for themselves? We investigated this issue in two research studies, involving three experiments. Scruggs, Mastropieri, McLoone, Levin, and Morrison (1987), in two experiments, developed mnemonic "textbooks" which provided both content and strategic information about mineral dichotomies (Exp. 1) and specific mineral attributes (Exp. 2). Control condition students read the identical passages, without specific strategy information, and with representative, rather than mnemonic, pictures. In both experiments, students who read mnemonic materials significantly outperformed students who read control materials; in Experiment 1, the mnemonic condition advantage was still evident after a one-week delayed recall interval. Furthermore, in Experiment 2, students who read mnemonic materials describing specific mineral information were more able than control condition students to infer attribute dichotomies. This latter finding provided further support that mnemonically instructed students comprehend better, as well as recall more, than students instructed by other methods.

In a second investigation (Mastropieri, Scruggs, & Levin, 1987a) we embedded mnemonic pegword illustrations relevant to ordered reasons for dinosaur extinction within "textbook" passages. In this experiment, we employed three conditions: mnemonic picture, picture control, and no picture control. We found that the representative picture control materials improved learning over the levels obtained by students in the no picture condition; however, only students in the mnemonic picture condition were able to accurately recall reasons for dinosaur with respect to their rated order of plausibility.

These two studies led us to believe that material development for classroom instruction was very possible, in that students had independently benefited from text-embedded mnemonic strategies. We next turned our attention to a careful evaluation of the interaction of mnemonic strategies with the pre-determined content of specific curriculum materials.

Grant-Supported Research Implementation Studies

At this point in our research, we began to feel confident that mnemonic strategies were potentially very powerful facilitators for students characterized as LD or MiMH (for reviews, see Mastropieri, Scruggs, & Levin, 1985a; 1987b). Over several "laboratory"-type investigations, we had found that such strategies resulted in consistently and substantially higher levels of performance than rehearsal-based instructional routines, on immediate as well as delayed recall measures. Furthermore, we found that several related pieces of information could be presented within a single mnemonic picture, and that this information could be represented literally, symbolically, or acoustically (with keywords or pegwords). We also had found that color could be used to represent or symbolize information, and that mnemonic pictures and strategies could be embedded within textbook-like reading materials. Also, we had seen that mnemonic instruction facilitates comprehension as well as recall, and that it could be implemented with small groups as well as individual subjects, and over several administration periods, without any observable negative effects from interference from previously-learned mnemonic systems.

During this research program, had any of our specific research questions resulted in negative or equivocal effects, we would have felt the necessity to revise our materials and/or procedures and conduct additional research in that particular area. The reason these studies consistently supported mnemonic strategy instruction was, we feel, partly due to the extraordinary power of these strategies, and partly due to the fact that we chose to conduct a series of investigations, in which each new investigation represented only a small departure from the previous investigation. Each successful investigation, then, provided us with additional information, which we were able to incorporate in the next investigation to increase the probability of success. We also felt that, taken together, a substantial number of replications would offer a more convincing case for the power of mnemonic instruction than would, for example, one very large scale investigation, in which several different variables were interacting simultaneously.

Textbook Analysis

With this body of research studies completed, we felt we were very close to attempting broad-based classroom applications of mnemonic instruction. The next step we took, then, was to evaluate actual classroom curricular materials with respect to their potential for mnemonic adaptation. The content we first examined was U.S. history during World War I. We decided to evaluate social studies before more conceptually difficult curricula such as science; we chose World War I because, if our adaptations proved to be effective, we wished to implement these materials during the second half of the year, and therefore chose a content not likely to have been covered in class by then.

The first thing we found in our textbook analysis was that not all information lent itself to keyword or pegword-type reconstructions. In attempting to uncover the reasons for this, we discovered that keyword-appropriateness was largely determined by the variables of concreteness and meaningfulness (or familiarity). That is, keyword reconstructions were most appropriate when information was non-meaningful to learners. As we had argued previously, "the recoding component of the keyword method serves to transform unfamiliar, nonmeaningful stimuli into more meaningful entities" (Mastropieri, Scruggs, & Levin, 1985a, p. 40). But what about information that was already familiar to learners? Such familiar information could include conditions of life at particular historical periods, and specific attributes of new inventions or weapons of war. In addition, we determined that familiar information could be either concrete or abstract. If information to-be-learned is both familiar and concrete, it could be easily pictured in a representative (or mimetic) drawing. However, abstract information, even though familiar to learners, could be difficult to picture. Such information could include such abstractions as justice, religion, Republicans, or U.S. policy. In cases such as these, it does not seem appropriate to establish semantically-irrelevant retrieval links (e.g., with keywords) when it may be possible to build on the underlying meaningfulness of the information. In these cases, then, symbolic reconstructions of the information can be made, substituting symbols such as scales, church, donkeys, or Uncle Sam, respectively, for the abstract concepts mentioned above. We had also found, from previous research, that attributes such as carnivore and hard/soft dichotomies could be effectively symbolized.

Reconstructive Elaborations

We therefore used this system of mimetic, symbolic, and acoustic (keyword) reconstructions to adapt the most important content covered in the relevant textbook chapters on U.S. involvement in World War I. Including a keyword-embedded first letter strategy for learning lists of information (e.g., countries of the Central Powers), we referred to the entire model as "reconstructive elaborations" (Mastropieri & Scruggs, 1989c,d). We evaluated its effectiveness by using these and picture-control materials to teach 31 important facts and concepts relevant to World War I (in 28 minutes of instruction), to 30 mildly handicapped high school students, individually, in a single session (Scruggs & Mastropieri, 1989a). We found that students who had been instructed via the "reconstructive elaborations" methods and materials learned nearly twice as much information as those taught using the picture control materials. We also found that all elements of the model -- mimetic, symbolic, acoustic, first letter -- resulted in significantly higher scores than did control presentations of the same information, and maintained a significant advantage over a 3-4 day delayed recall interval. The results of this investigation underlined the value of an overall model of elaborative strategies in special education, and paved the way for research implementations.

Classroom Implementations

Design Considerations

Having determined that the materials themselves were effective in promoting learning and retention, we felt that we were ready to attempt classroom implementations of these mnemonic methods and materials. In conducting such classroom-based research, some experimental control will almost certainly be lost. Under actual classroom circumstances, instruction may not always be delivered precisely as intended, subject attrition or interference can inhibit research findings, random assignment to treatment conditions can be difficult or impossible, and classroom factors, such as teacher variables, peer interactions, or time of day constraints can seriously compromise the validity of study outcomes.

Classroom-based research is not only more expensive in time and resources to implement, it is more difficult to monitor. An ideal research design involves the random assignment of perhaps 10 - 20 classrooms per condition to treatment conditions, and the use of each classroom mean score (or subject scores treated as nested effects) as the appropriate unit of analysis. Such a design could effectively control for classroom effects, teacher effects, and non-independence of data resulting from treating each student as the appropriate experimental unit. Such designs, however, are extremely difficult in practice to set up and monitor. Even if sufficient resources are available to conduct such research, the difficulties inherent in monitoring fidelity of implementation will likely result in a loss of experimental control that will more than compensate for any statistical advantages gained from the design.

Nevertheless, we do feel that researchers should strive to avoid the type of classroom X treatment confounding that results from assigning a small number of classrooms (e.g., one per treatment) to treatments and treating each student in each classroom as an independent unit. We have attempted to address these problems with the use of within-subject designs, in which each student receives each treatment, in counterbalanced order, and therefore serves as his or her own experimental control.

For classroom research implementation studies, then, design considerations should be different than those described for laboratory-type experiments. These considerations, we feel, should include the following:

1. Base classroom research as literally as possible on previously conducted laboratory-type research with very rigorous experimental designs. If findings of classroom applications replicate previous experimentally-rigorous laboratory-type studies, they will be less susceptible to question.
2. Use of several, rather than one, classroom, to eliminate, as much as possible, effects due to particular classroom factors.
3. When random assignment is not possible (and it very frequently is not), within-subjects designs can be very effective alternatives. In addition, within-subject designs are more powerful statistically, and better protect against attrition effects -- each subject is his or her own control, so that when subject attrition occurs, it can not differentially affect experimental conditions. "Carryover" or transfer effects are potential problems with these

designs, but can be directly assessed with careful planning of treatment orders and strategy questioning.

4. Potentially confounding variables such as treatment order or chapter difficulty can be addressed in within-subject designs by counterbalancing such factors across classrooms.

5. Many replications of classroom-implementation research studies should be planned, as a number of replications will help establish the validity of findings.

Results

We first implemented classroom-based mnemonic instruction in three junior-high school self-contained classrooms, in a within-subjects design (Scruggs & Mastropieri, 1989b). In this design, students received the World War I chapter mnemonically, the Roaring 20s chapter traditionally, the Depression-era chapter mnemonically, and the World War II chapter traditionally, in an "A-B-A-B" type design. Analysis of the results indicated that students learned far more information when instructed mnemonically. Furthermore, average weekly grades, "D+" under traditional instruction, increased to "Bs" under mnemonic instruction.

One limitation of this study was the fact that some chapters were taught mnemonically while others were not. Such a limitation leaves open the alternative explanation that the World War I and Depression chapters were simply easier chapters than were the Roaring 20s and World War II chapters. Although such an explanation seems unlikely in light of the volume of previous research, it nonetheless needed to be addressed. We planned an additional experiment (Mastropieri & Scruggs, 1988), in which each of four classrooms received different mnemonic and traditional chapters, in a different order. Each chapter was covered over a period of two weeks. Classroom 1 received instruction in order A-B-A-B (in which A = traditional instruction and B = mnemonic instruction); classroom 2 received order B-A-B-A; classroom 3 received order A-A-A-B; and classroom 4 received order B-B-B-A. In classroom 4, we wished to test additionally whether we would observe any spontaneous transfer of mnemonic strategies, after six weeks of mnemonic instruction.

Results replicated the findings from the previous U.S. history investigation, in that students when instructed mnemonically scored much higher on tests, including recall tests of up to eight weeks of instruction, than when they were instructed traditionally. Additionally, teachers rated mnemonic instruction as significantly more appropriate for LD students, and students also strongly favored the mnemonic condition.

Findings of the Mastropieri and Scruggs (1988) investigation have since been replicated and extended, using similar within-subject, "crossover" research designs. Content has included U.S. History (French and Indian & Revolutionary Wars) in a mainstream setting (Mastropieri & Scruggs, 1990); state (Indiana) history (Mastropieri & Scruggs, 1989b); U.S. states and their capitals

(Mastropieri, Scruggs, & Bakken, 1990); as well as earth and life science content (Scruggs & Mastropieri, in press a). These four investigations all involved two- to four-week classroom implementations, and revealed very positive effects of mnemonic instruction on recall and attitude toward instruction. In a separate investigation involving science content, Mastropieri, Emerick, and Scruggs (1988) employed teacher-constructed materials, which included stick figures and cutouts from magazines, to test whether such teacher made materials could also be effective. In all investigations, it was found that mnemonic instruction resulted in far greater levels of achievement than did more traditional teacher presentations.

Transfer

In a set of experiments (Scruggs, Mastropieri, Jorgensen, & Monson, 1986; Scruggs & Mastropieri, 1988), we had found that highly able ("gifted") students could spontaneously (i.e., without training) transfer mnemonic strategies to novel tasks, with little or no prompting. Normally-achieving students, under the same set of conditions, were much less successful at transferring the strategy. Furthermore, our implementation studies had demonstrated that spontaneous transfer did not occur with LD students, even after six weeks of mnemonic teaching of similar content! Clearly, if LD students were to begin to use mnemonic strategies independently, specialized training procedures would be necessary.

We had previously addressed the issue of student transfer of mnemonic techniques to independent learning (Mastropieri, Scruggs, Levin, Gaffney, & McLoone, 1986; McLoone, Scruggs, Mastropieri, & Zucker, 1986); however, we had not attempted it previously in an implementation study. Scruggs and Mastropieri (in press a), after implementing three weeks of mnemonic instruction in life and earth science, taught an additional chapter in earth science using a procedure whereby mnemonic strategies were generated collectively by the class. Students then drew the mnemonic illustrations in their workbooks. Although overall level of recall of these student-generated mnemonics was very high, it was also found that less than half the content was covered under this condition, as compared with teacher-provided mnemonic units. We concluded that mildly handicapped students could generate their own mnemonic strategies, and that these strategies were very effective, on the whole. However, we argued that, given the extra time necessary for students to generate such complex strategies, teachers must decide whether the content or the strategy is of the most importance in specific teaching situations. If the strategy is more important than the content being used to teach the strategy, then such strategy training is justifiable. If, on the other hand, the content in question is of the most importance, then teacher-provided mnemonics should probably be employed.

As a final generalization study, Fulk (1990; reported in

Fulk, Mastropieri, & Scruggs, 1990) provided mnemonic strategy generalization training that incorporated attributional retraining with 56 sixth through eighth grade learning disabled students. Subjects were randomly assigned to one of three individually administered treatment conditions: mnemonic generalization training, mnemonic generalization training combined with attribution retraining, and a directed rehearsal comparison. This design allowed comparison of LD subjects' performance across experimental conditions on recall of information in each of three phases: training, prompted transfer, and unprompted transfer. Subjects were taught varied content during each experimental phase. The first phase emphasized training of the condition-specific strategy with experimenter provided pictures. The second phase was a guided practice prompted transfer phase. Phase three occurred at one-day and two-week delay intervals to assess unprompted generalization. Three dependent variables were collected and analyzed for each day of the investigation: (a) production tests, (b) identification tests, and (c) strategy reports. In addition, the one-day delayed task was followed by a backward retrieval test. Additional measures that followed the two-week delayed task were: backward retrieval, cumulative delayed test and a postintervention attribution assessment. Strategy report information was categorized and analyzed relative to levels of strategies employed. Data were analyzed with Analyses of

Covariance, using psychometric intelligence test scores as covariates, and appropriate post hoc comparisons. Significant differences were found favoring the mnemonic conditions on prompted transfer tasks on the second and third day of instruction. Mnemonic condition students also outperformed directed rehearsal condition students on a two-week delayed transfer task to different content. Fulk, Mastropieri, and Scruggs (1990) concluded that a three-day mnemonic generalization training program could be used to promote transfer of mnemonic strategies to different content, at least two weeks subsequent to training. The additional attributional retraining apparently had little or no effect on generalization performance.

Independent Replications

In addition to the work described above, there have been a number of additional research studies conducted by others which have made substantial contributions to the area of mnemonic strategy instructional research. To our knowledge, all of these investigations have been based on doctoral dissertation research. Such research investigations are important not only to answer additional research questions, but also to provide important external validity to the work of other researchers. For instance, a specific instructional technique may be found to be generally effective, but is only effective when certain individuals conduct the research. Such a finding would suggest that some perhaps unstated component of the success of the research is strongly tied to the individuals conducting the research. This would therefore strongly limit the external validity of the findings. On the other hand, work from one researcher or group of researchers which is replicated by independent researchers strongly argues for the external validity of that research.

Mnemonic instructional research in special education has very recently been conducted by researchers working independently from the present authors (Laufenberg, 1985, reported in Laufenberg & Scruggs, 1986; McLoone, 1985; Tolfa-Veit, 1985; were also dissertations involving mnemonic strategy research, but were not conducted independently of the present authors). To our knowledge, all of these dissertations have supported our findings regarding the powerful learning effects produced by these strategies. Taylor (1981) conducted an initial vocabulary study in which keyword-instructed LD students far outperformed controls; however, the provision of the keyword to mnemonic condition students during testing provided (we felt) an unfair prompt to the experimental condition. Berry (1986) provided less equivocal support for keyword-based vocabulary instruction, in that unprompted LD students instructed mnemonically far outperformed controls, in each of two experiments. Yuen (1985) provided evidence that MiMH students could be taught abstract vocabulary with the keyword method, although his results were somewhat obscured by floor effects, perhaps as a result of insufficient instructional time. Condus (1984; reported in Condus, Marshall, & Miller, 1986) demonstrated that keyword vocabulary instruction was very effective when implemented in LD classroom settings over five weeks of instruction; Powell-Brown (1989) reported that keyword vocabulary instruction resulted in higher levels of LD students' learning and recall than a "semantic mapping" condition; and King (1989) provided additional support that LD students could use keyword strategies in learning content-area terminology. These six dissertations, taken together, provide independent support for the positive effects of keyword vocabulary instruction.

Additionally, dissertations by Willott (1982) and Greene (1988) have investigated the use of pegword strategies to facilitate the learning of multiplication tables. Using somewhat different strategies, both reported that mnemonic instruction had promoted more efficient acquisition of math facts.

Altogether, then, the results of these eight dissertations suggest that there are few, if any, "researcher effects" in the line of research we have described. Taken with our approximately two dozen studies, we feel that the previous potential of mnemonic instruction has become a present reality.

The Future

To date, we have found that mnemonic instructional methods and materials, both teacher and researcher-developed, can produce dramatic gains in classroom learning for special education students. (For support of our claim that these are the most effective strategies ever experimentally investigated in special education, see Mastropieri & Scruggs, 1989a). In spite of the quantity of research to date on the use of mnemonic techniques in special education, we feel that there is still a great deal of research to be conducted. We believe that mnemonic instruction of the type similar to that described here could be very helpful in facilitating the acquisition of basic skills, such as phonics (Ehri, Deffner, & Wilce, 1984) and spelling, and mathematics operations, perhaps using the "Yodai" method (Machida & Carlson, 1984). Whether or not such strategies are ultimately helpful for mildly handicapped students, however, awaits further research. Likewise, further research on the independent transfer of mnemonic strategies remains to be completed. Again, we feel that any such research should parallel the development we have described here: specific strategies should be validated in laboratory-like settings, and, if effective, evaluated again in small group, and then in classroom presentations. As such research evolves, the designs and materials used in these studies should also evolve.

Conclusions

Results of several years of laboratory-type investigations had previously indicated that mnemonic instructional techniques had great potential in improving the learning and memory of mildly handicapped students. As a result of the present three-year, federally-funded grant project, we can confidently add that classroom textbooks can be adapted to mnemonic instructional materials, and implemented in special education classrooms for extended time periods. When this is done, remarkably strong learning effects can be obtained in areas such as American history, state history and social studies, geography, life science, earth science, and earth history (Scruggs & Mastropieri, 1990). These effects have been seen to maintain for delayed recall periods of as high as eight weeks.

In addition, we have seen that students can be taught to generate their own mnemonic strategies when prompted by the teacher during the course of instruction and when trained independently by experimenters. Trained students have been seen to successfully generate their own effective mnemonic strategies to substantially different content, unprompted and at least two weeks after training. Although the generalization effects have shown that LD students can be trained to significantly improve their own learning, students generating their own strategies have learned less content, and learned it less well than when previously developed mnemonic strategies are provided to them by teachers. When considering training procedures, teachers will need to determine whether, for particular units of instruction, the content, or the strategy, is of most importance.

We have argued that applied research should be firmly grounded in theories of learning and instruction, as well as theories of specific disability areas. Initial research, testing the potential of such strategies under optimal experimental circumstances, provides a necessary first step in validating and refining the specific instructional strategies (for another opinion, see Shepherd & Gelzheiser, 1987; and Pressley, Scruggs, & Mastropieri, 1989, for our response).

Once strategies have been thoroughly tested in one-to-one laboratory situations, using a number of strategy variations, they should be tested in small group situations, as well as independent learning situations. Additional content adaptations should be tested, including investigations of the effects of repeated strategy presentations. If such investigations are positive with respect to the strategy being studied, applications in "real" classroom settings are necessary to provide external validity. Throughout this program of research, we have argued that small, replicated extensions, conducted frequently over time, provides the greatest overall support for the strategies. Replications by independent researchers are also critical to establish the overall value of these strategies. The final step in any research program, is for individual teachers to validate the strategies in their own classrooms, using formative evaluation techniques (Mastropieri & Scruggs, 1987).

After a decade of mnemonic research, we feel sufficiently confident in the power of these methods that we can generally recommend their use by special education teachers. In a forthcoming issue of Learning Disability Quarterly, devoted to memory and learning disabilities (Scruggs & Mastropieri, in press b) we make such a recommendation (Mastropieri & Scruggs, in press a). Additionally, we have recently completed a book (Mastropieri & Scruggs, in press b) in which we described precisely how such strategies can be developed, for a variety of classroom applications. Nevertheless, if we feel positive about the use of mnemonic instructional techniques, we hope that support is limited to their continuing empirical support in the research literature. We hope we will be able to play a role in contributing to this future research support.

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*Indicates grant-sponsored publications.

Dissemination Products Resulting from Grant #G008730144

Dissertation

Fulk, B.J.M. (1990). An investigation of mnemonic generalization training and attribution retraining with learning disabled adolescents. Unpublished doctoral dissertation, Purdue University, West Lafayette, IN.

Book Chapter

Mastropieri, M.A., & Fulk, B.J.M. (1990). Enhancing academic performance with mnemonic instruction. In T.E. Scruggs & B.Y.L. Wong (Eds.), Intervention research in learning disabilities (pp. 102-122). New York: Springer-Verlag.

Journal Articles and Manuscripts

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Scruggs, T.E., & Mastropieri, M.A. (in press b). Effective mainstreaming strategies for mildly handicapped students. Elementary School Journal.

Book

Mastropieri, M.A., & Scruggs, T.E. (in press). Teaching students ways to remember: Strategies for learning mnemonically. Cambridge, MA: Brookline Books.

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*Chapter, Articles, and Manuscripts are included in the Appendix, in the order they appear here.

Presentations

1991 (Scheduled)

Mastropieri, M.A., Hesser, S., & Sullivan, S. (1991, April). Enhancing school success with mnemonic instruction. Paper to be presented at the annual meeting of the Council for Exceptional Children, Atlanta.

Mastropieri, M.A., & Scruggs, T.E., & Bakken, J., Anders, S., & Brigham, F. (1991, April). Learning states and capitals with mnemonic instruction: Facilitating forward and backward associations. Paper to be presented at the annual meeting of the American Educational Research Association, Chicago.

Scruggs, T.E., & Fulk, B.J.M. (1991, April). Mainstream strategies that really work! Paper to be presented at the annual meeting of the Council for Exceptional Children, Atlanta.

1990

Mastropieri, M. A. (1990, April). Advances in cognitive strategy intervention research with learning disabled youth. Chair, Symposium at the annual meeting of the American Educational Research Association, Boston.

Mastropieri, M. A., & Fulk, B. J. M. (1990, April). Using mnemonic strategies to enhance the learning of content area information. Paper presented at the annual meeting of the American Educational Research Association, Boston.

Mastropieri, M. A., Scruggs, T. E., & Fulk, B. J. M. (1990, April). Acquisition of abstract and concrete vocabulary concepts. Paper presented at the annual meeting of the American Educational Research Association, Boston.

Mastropieri, M. A., Scruggs, T. E., Fulk, B., Shiah, S., Brigham, F., Anders, S., Bakken, J., Hesser, S., & Milham, T. (1990, February). Enhancing school success with mnemonic instruction. Paper presented at the annual meeting of the Indiana Federation Council for Exceptional Children, Indianapolis.

Scruggs, T. E., & Mastropieri, M.A. (1990, April). Classroom applications of mnemonic instruction: Acquisition, maintenance, and generalization. Paper presented at the annual meeting of the American Educational Research Association, Boston.

Scruggs, T.E., & Mastropieri, M.A. (1990, October). Effectiveness of special education interventions. Invited keynote address presented at the annual meeting of the Iowa Council for Exceptional Children, Des Moines.

Scruggs, T.E., & Mastropieri, M.A. (1990, November). Mnemonic instruction for behaviorally disordered students. Paper presented at the annual meeting of the Teacher Educators of Children with Behavioral Disorders, Tempe, AZ.

1989

Mastropieri, M. A. (1989, March). Adapting content area information to improve learning and memory performance of

students with learning and memory strategies. Invited address to the State of Iowa's Innovative Practices in Special Education Conference, Cedar Rapids, IA.

Mastropieri, M. A. (1989, March). *Memory, learning, and teaching*. Invited crackerbarrel session at Innovation Practices in Special Education Conference, Cedar Rapids, IA.

Mastropieri, M. A. (1989, March). *Discussant to: The interdependence of research on cognitive strategy instruction and the practice of cognitive strategy instruction*. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Mastropieri, M. A. (1989, March). *Chair: Individual differences in spatial learning and computer attitudes*. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Mastropieri, M. A. (1989, November). *Social studies can be multisensory: New ways to actively involve students in the learning experience*. Invited paper presented at Columbia University's Building Study Skills and Learning Strategies for Learning Disabled Students Conference, Teachers College, Columbia University, New York.

Mastropieri, M. A. (1989, July). *Translating research into practice: Issues surrounding the design of classroom based research*. Invited presentation at the 1989 Office of

Special Education Project Directors' Conference, Washington, D.C.

Mastropieri, M. A., & Scruggs, T. E. (1989, September). Facilitating learning with mnemonic instruction. Paper presented at the Council for Exceptional Children/Council for Children with Behavior Disorders, Topical Conference on Behavior Disorders, Charlotte, NC.

Mastropieri, M. A., & Scruggs, T. E. (1989, November). Mnemonic instruction for behaviorally disordered students. Paper presented at the annual Conference on Severe Behavior Disorders in Children and Youth, Tempe, AZ.

Mastropieri, M. A., & Scruggs, T. E. (1989, November). Mnemonic instruction for special populations. Invited presentation for the Kennedy Center, George Peabody College, Vanderbilt University, Nashville.

Mastropieri, M. A., Scruggs, T. E., & Fulk, B. F. (1989, March). Teaching abstract vocabulary with the keyword method: Effects on recall and comprehension. Paper presented at the American Educational Research Association, San Francisco, CA.

Scruggs, T. E., & Mastropieri, M. A. (1989, March). Reconstructive elaborations: A model for content area learning. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Scruggs, T. E., Mastropieri, M. A., Fulk, B. J. M., Milham, T., Shiah, S., & Baker, L. (1989, February). Improving LD students' content area learning. Paper presented at the annual meeting of the Indiana Federation of the Council for Exceptional Children, Indianapolis, IN.

1988

Mastropieri, M.A. (1988, November). Mnemonic instruction for learning disabled students. Invited paper presented at the Division for Learning Disabilities Symposium: Intervention Research, Purdue University, West Lafayette, IN.

Mastropieri, M. A. (1988, April). Chair/Discussant: Learning strategies and dynamic assessment. Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

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Scruggs, T. E., & Mastropieri, M. A. (1988, April). Acquisition and transfer of learning strategies by gifted and non-gifted

students. Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

Scruggs, T. E., & Mastropieri, M. A. (1988, November). Increasing the learning and memory skills of behaviorally disordered students. Paper presented at the Twelfth Annual Conference on Severe Behavior Disorders of Children and Youth, Tempe, AZ.

Appendix: Chapter, Journal Articles, and Manuscripts

Appendix A

Mastropieri, M.A., & Fulk, B.J.M. (1990). Enhancing academic performance with mnemonic instruction. In T.E. Scruggs & B.Y.L. Wong (Eds.), Intervention research in learning disabilities (pp. 102-122). New York: Springer-Verlag.

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Enhancing Academic Performance with Mnemonic Instruction

MARGO A. MASTROPIERI AND BARBARA J. MUSHINSKI FULK

This chapter describes recent advances in mnemonic (memory enhancing) instruction with learning disabled populations. Particular emphasis is given to several long-term classroom interventions in which we have adapted classroom materials to incorporate the use of specific mnemonic strategies in the science and social studies areas. In these classroom-based interventions, a wide variety of dependent measures have been employed including: immediate and long-term recall tests, interviews regarding strategy usage, students' and teachers' attitudes toward mnemonic instruction, students' ability to generate such strategies independently, and students' overall weekly assigned class grades. All results to date indicate that: (a) students' academic performance on immediate and delayed recall measures increased significantly under mnemonic instructional conditions; (b) students reported enjoying instruction more under mnemonic instructional conditions; (c) mnemonically instructed students accurately reported the specific strategies used to retrieve the information; (d) students reported wanting to use similar mnemonic instructional procedures for other academic areas; (e) teachers reported enjoying the use of the mnemonic materials; (f) teachers stated that students appeared more motivated to learn under mnemonic instructional conditions; and (g) teachers reported that students participated more during instruction under mnemonic instructional conditions.

First, some initial mnemonic instruction investigations that occurred in laboratory-type settings using experimental materials are described. The results of these investigations were promising and provided the foundation for further investigations, although they themselves provided little information for long-term classroom applications of these strategies. Second, the development and expansion of the model, "reconstructive elaborations," for adapting all content areas to mnemonic instruction is presented. Third, long-term classroom implementation studies in social studies and in science are described. Finally, assumptions regarding the underlying theoretical support for the explanations of the success of mnemonic instruction with learning disabled populations are provided.

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Initial Investigations

Interest in memory-enhancing devices has existed for centuries. Some historians report that training in specific mnemonic techniques was common practice before the invention of the alphabet and printing press (see Yates, 1966, for a review). Even empirical investigations in mnemonics have been conducted for several decades (e.g., Bower, 1970), although much of this initial work was aimed at differentiating between verbal and imaginal processes, rather than at increasing learning per se. Simultaneously, some researchers investigated the use of mnemonic techniques involving simple verbal elaborations with retarded populations (e.g., Jensen & Rohwer, 1963). More recently, however, Pressley and his colleagues employed mnemonic techniques in investigations with school-age populations with the primary intent of determining the effects on learning (e.g., Pressley, Levin, & Delaney, 1982). Results of these investigations provided some of the initial directions for research with learning disabled students that followed. The latter investigations are described below, first under vocabulary studies, then under attribute studies.

Vocabulary Studies

Some early investigations using specific mnemonic procedures to teach learning disabled (LD) students vocabulary words were conducted by Mastropieri, Scruggs, Levin, Gaffney, and McLoone (1985). In a study containing two experiments, junior high school LD students were taught English vocabulary words using experimenter-provided illustrations (Exp. 1), or student-generated elaborative images (Exp. 2). Results of both experiments indicated that mnemonically instructed students outperformed students in a directed instruction control condition. Additionally, students in the condition with the experimenter provided illustrations recalled more than those in the condition with student generated images.

In a followup investigation McLoone, Scruggs, Mastropieri, and Zucker (1986) examined the transfer of these mnemonic strategies across lists of English and Italian vocabulary words. Junior high school LD students were taught to use the mnemonic strategy or to use a directed rehearsal approach. The results paralleled those of the earlier vocabulary studies in that mnemonically instructed students successfully transferred the strategy and recalled more than their control counterparts. Veit, Scruggs, and Mastropieri (1986) added evidence that LD middle school-aged students significantly outperformed their control subjects in learning the roots of Greek words. In that investigation, students successfully maintained the learning on surprise delayed recall measures.

In a more recent study, Mastropieri, Scruggs, and Fulk (in press) extended the results of the previous studies. In this study, abstract vocabulary words were selected as target materials, and comprehension as well as re-

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call measures were employed. Again, junior high school LD students in the mnemonic condition not only recalled more abstract words, but also "comprehended" more words than control students. Taken together, the results of the vocabulary studies indicated that: (a) LD students could achieve superior performance on vocabulary tasks using the keyword method on both immediate and delayed recall measures; (b) LD students generated elaborative interactions and transfered the strategy to similar task; and, (c) LD students' comprehension of abstract vocabulary was enhanced using these strategies.

Attribute Studies

Simultaneous with the series of vocabulary studies, we conducted parallel studies to examine the instruction of information that contained multiple attributes, rather than only a single definition as in vocabulary tasks. Mastropieri, Scruggs, and Levin (1985a), for example, taught ninth-grade LD students the hardness levels of minerals using a combined keyword-pegword strategy. Mnemonically instructed students outperformed students in the control conditions of free-study control and direct questioning on both an immediate and a surprise delayed recall test. In a followup study, it was found that this type of instruction could be delivered successfully in small group instructional formats (Mastropieri, Scruggs, & Levin, 1986).

Although these results provided positive findings, it was unknown whether or not LD students could learn more than one or two pieces of information mnemonically. In other words, would LD students begin to confuse the mnemonic images as more and more information was presented to them? In a series of followup studies designed to address this question, LD students were taught multiple attributes of minerals (color, hardness, and use) in three instructional conditions: a combined mnemonic strategy, free study, or direct instruction. Results indicated that mnemonically instructed students significantly outperformed those in the two control conditions. In a followup study, Mastropieri, Scruggs, McLoone, and Levin (1985) used dichotomies (e.g., hard vs. soft mineral, pale in color vs. dark in color, used in the home vs. used in industry) of the same information and found that mnemonically instructed students outperformed students in the control conditions. Several additional studies were conducted to answer the following questions: (a) the extent to which visual-spatial display treatment would compare with mnemonic conditions (Scruggs, Mastropieri, Levin, McLoone, Gaffney, & Prater, 1985); (b) whether prose passages that were embedded with mnemonic illustrations could facilitate learning (Mastropieri, Scruggs, & Levin, 1987a; Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1986); and (c) whether several days of related instruction using mnemonic strategies could enhance learning (Veit, Scruggs, & Mastropieri, 1986). In all cases, students who

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were instructed with mnemonic strategies consistently outperformed their control counterparts. All findings indicated: (a) increases on immediate and delayed recall measures; (b) increases on application and comprehension measures; (c) ability to benefit from multiple attributes; (d) ability to generate elaborative images; (e) ability to transfer strategy to a similar tasks; and (f) ability to independently read and execute the strategic information (see Mastropieri, Scruggs, & Levin, 1985a; 1987b; and Scruggs, Mastropieri, & Levin, 1987 for previous reviews). These cumulative results provide the empirical foundation necessary for the development of a comprehensive model for adapting content area information in which mnemonic strategies can be engaged.

Development of the Reconstructive Elaborations Model

The findings from the vocabulary studies and the multiple attribute studies show that although many fruitful applications could be drawn from the cumulative data, almost as many limitations could be listed regarding actual research implementations in classrooms over time involving actual school content. These limitations included the following: (a) materials were developed by researchers; (b) materials were implemented by researchers; (c) materials were typically limited to single, short lessons, with the exception of the Veit, Scruggs, and Mastropieri (1986) study.

In an effort to address the ultimate utility of this type of mnemonic instruction with actual school content, it became apparent that further extensions would have to be made. Toward this end, Scruggs and Mastropieri (1989b) examined a variety of U.S. history textbooks at several grade levels and completed a content analysis of those materials. It soon became obvious that the information presented in those textbooks contained many types of pieces of information that need to be learned as associates. For example, names of famous people were presented, along with their respective accomplishments. Second, names of places and events that were associated with those places were frequently emphasized. This was especially apparent in the chapters that presented information on wars and those that covered explorations of new lands. Third, descriptions of novel items and their respective associates were presented, as in the case of new weapons and their associated uses and effects. Fourth, conditions of life during specific time periods were described, such as life during the pioneer days, the roaring twenties, the depression, or even the sixties. Finally, it appeared that sometimes several pieces of information needed to be recalled together, such as the names of the northern states versus the names of the southern states during the Civil War, or the products associated with specific cities, states, or regions, or the countries in the Allied Powers during World War I.

Along with this analysis, two points soon became very obvious. First,

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much of the information presented in the textbooks did not lend itself to the keyword type reconstructions that we had used in our earlier studies. Second, much of the to-be-learned information was already familiar, meaningful, and concrete to the target learners. In contrast, in the previous investigations, much of the information taught to LD students had been totally unfamiliar and nonmeaningful. In fact, we found that we could reliably classify target information along "meaningfulness" and "concreteness" dimensions, ranging from totally nonmeaningful to partially meaningful, and from abstract to meaningful and concrete with respect to a particular target population.

In an attempt to validate the reconstructive elaborations model, Scruggs and Mastropieri (1989b) designed an investigation in which the chapter on World War I from the locally adopted U.S. history textbook (Rawls & Weeks, 1985) was adapted to incorporate the various types of mnemonic systems based upon the level of meaningfulness and concreteness for the target population. Junior and senior high school LD and mildly mentally handicapped (MiMh) students were selected as the target population. Then, the to-be-learned content was classified as: (a) meaningful/concrete, (b) partially meaningful/abstract, or (c) not meaningful and neither concrete nor abstract. Descriptions of the specific reconstructions that were made to accommodate each of those classifications in the validation study are described below.

Acoustic Reconstructions

Acoustic reconstructions were employed whenever the content was totally unfamiliar to the target population. For example, in the World War I chapter, numerous famous people are introduced with concomitant associated events for which they were considered famous or important. Some of the many unfamiliar names include: William Jennings Bryan, Pancho Villa, Woodrow Wilson, Gavrilo Princip, Archduke of Austria-Hungary, Eddie Rickenbacker, George M. Cohan, General Pershing, the Zimmerman incident, the *Lusitania*, Central Powers, Allied Powers, and Alliance System, just to name a few. The associated important information for each of the above unfamiliar names was also unique to each name. For example, William Jennings Bryan was President Woodrow Wilson's Secretary of State. Bryan was also considered a pacifist at the beginning of World War I. We assumed that the name Bryan was totally unfamiliar to our LD and MiMh students, so the name Bryan was reconstructed to an acoustically similar, but familiar and concrete term, "lion," as in the manner that the earlier keyword vocabulary studies were conducted (see Mastropieri et al., 1985). The lion was portrayed interacting with the to-be-remembered information of "Secretary of State and Pacifist" by showing a picture of a lion sitting at a secretary's desk saying please "no fighting" to two other animals who were starting to fight in front of the secretary's desk. In the present example

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"opposed to fighting" was depicted rather than pacifist, because the word pacifist was unfamiliar to the target learners.

Acoustic reconstructions similar to the Bryan example were developed for any piece of information that was considered to be important to learn and totally unfamiliar to the learners. Notice that in using the acoustic reconstruction, we were relying upon the "acoustic" properties of the word that *are familiar* to the target population. In other words, the only thing familiar about this word is *its acoustic resemblance to something that is familiar and easily pictured* to the target population. Following that, an elaboration was constructed in which stimuli and response information were depicted interacting in an illustration.

Symbolic Reconstructions

We also encountered information in the World War I chapter that was familiar but abstract to our target population. For example, the notion of U.S. policy was meaningful, but abstract. U.S. policy was symbolized as "Uncle Sam," a more concrete instantitation of U.S. policy, and then Uncle Sam was shown interacting with the to-be-associated information. In the present example, the U.S. policy at the beginning of World War I was neutrality. Therefore, a picture of Uncle Sam standing on the U.S. side of a globe while saying: "It's not my fight!" (to Europe who was fighting) was shown.

Similarly, we symbolized the "League of Nations" as a baseball league, who assembled to "provide protection, independence, and security for all nations involved." We found that the most critical element of the symbolic reconstructions to be the notion of prerequisite "partial knowledge" about the relevant concept being symbolized. If, for instance, the target population were unfamiliar with the initial concept, an acoustic reconstruction, rather than the symbolic reconstruction might be more appropriate.

Mimetic Reconstructions

We also encountered information that was already meaningful and concrete for our target population. During World War I, for example, many types of new weapons were introduced, including poison gas, gas masks, airplanes, tanks, trench warfare, submarines, and various types of naval ships. This type of information is probably meaningful and concrete to most LD and MiMh junior and senior high school populations. What is unknown to them, however, is the specific to-be-associated information. In the case of trench warfare, for example, the textbook authors stressed that much of the war was fought from the trenches and that the conditions of life in those trenches became so unhealthy that many soldiers contracted illnesses and died from the unhealthy conditions. However, the illustrations in the textbooks were pictures of soldiers in trenches looking healthy

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and posing for the photograph, rather than looking ill. We therefore, reconstructed that information into an elaborative illustration depicting "sick soldiers in the trenches." Similarly, we depicted soldiers putting on gas masks as protection from the poison gas that was being shot at them. Likewise, we reconstructed mimetic interactions of "tanks" going from trench to trench and providing protection from gunshot for the soldier inside, in order to associate the relevant information with tanks.

Validation Study

To assess the potential usefulness of each type of reconstruction, we developed eight acoustic reconstructions, eight symbolic reconstructions, eight mimetic reconstructions, and two first letter strategies using acoustic reconstructions as described above. The first letter strategies were designed to teach the names of the countries in each alliance system. For example, to learn that Turkey, Austria-Hungary and Germany were the countries in the Central Powers, a first letter strategy TAG (*T*urkey, *A*ustria-Hungary, *G*ermany) was made and children playing TAG in *Central Park* was shown. Central Park was the acoustic reconstruction for Central Powers. Similarly, a FIRE in an *Allied Van* was shown to represent the countries *F*rance, *I*taly, *R*ussia, and *E*ngland in the Allied Powers. These reconstructions represented the major content presented in the World War I chapter. Each reconstruction was presented on a page that contained the textual information and interactive illustration depicting the strategic information. We also developed a set of control condition materials that contained identical textual information, and representational illustrations similar to the ones found in the textbooks, rather than the interactive reconstructive elaborations. We then randomly assigned special education students to either a mnemonic instruction or a representational picture control condition and taught those students the information on World War I. Students were taught individually the information for equivalent amounts of time, and were tested immediately upon completion of the instruction and after delay intervals of three or four days.

The results indicated that students learned significantly more information under the mnemonic instructional condition than under the control condition. We further found, as we had originally hypothesized, that the greatest effect sizes were for the acoustic reconstructions, followed by the symbolic, and finally mimetic reconstructions. In other words, as the information became less meaningful, students in the control condition learned less information.

These findings were encouraging for several reasons. First, they demonstrated that specific mnemonic strategies could be developed from textbook content. These mnemonic strategies were based upon a model of meaningfulness and concreteness to the target population, and relied upon using interactive elaborations for linking the stimulus and response information.

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Second, the findings demonstrated that LD and MiMh students' performance could be significantly enhanced with instruction that utilized these mnemonic strategies on both immediate and delayed recall measures. Finally, the findings suggested a framework for research and direction for efforts to extend the model. The immediate extensions of the model involve implementation studies of mnemonic instruction in social studies and science.

Social Studies Research Implementation Studies

We began our research implementation studies by examining materials such as textbooks, teachers' guides, resource materials, and curricular guides adopted by several school districts in Indiana in the areas of U.S. history and state and local history. We also met with teachers and social studies specialists of the participating school districts and solicited input regarding "what's taught" in those content areas. We then targeted specific "eras" of history for our research implementation projects. The next phase of the research involved "identifying" the most important information to be mastered in those "eras" by the special education students. In identifying this content, we selected information presented from all available sources, and attempted to prioritize the information. This step involved making decisions regarding the elimination of some information that others might select as "important," but in our collective judgment was "not as important" as other information. Approximately 20 to 35 pieces of information per textbook chapter from the targeted U.S. history and state history areas were selected. We then proceeded, as described above, to determine the levels of meaningfulness and concreteness of that information for the targeted populations. Following that, the reconstructive elaborations to assist in teaching that important information were developed (see Mastropieri & Scruggs, 1989a, 1989b for specific procedures). The specific social studies' implementation studies are now described.

U. S. History

The first research implementation study involved the teaching of several chapters of U.S. history content to inner-city junior high school aged special education students (Scruggs & Mastropieri, 1989). We developed mnemonic illustrations for another chapter of U.S. history content, and added several illustrations to the World War I chapter. Therefore, mnemonic materials for the content on World War I and the Great Depression or the 1930s were developed. We then trained a special education teacher to use the mnemonic materials and the teacher effectiveness variables, as described in Mastropieri and Scruggs (1987), to teach the traditional and mnemonic instruction. This teacher was the U.S. history teacher for three classes of special education students. She then delivered the content in the

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following way: The first two weeks were mnemonic instruction covering the World War I information. The next two weeks were traditional instruction covering the Roaring Twenties. The following two weeks were mnemonic instruction covering the Great Depression. The final two weeks were traditional instruction covering World War II. At the end of each instructional unit the teacher administered multiple choice tests covering the content that had been instructed. The teacher also assigned grades to all students based upon their class participation, as well as their class and homework assignments completed throughout the eight weeks of instruction. Additionally, we asked the teacher to complete Behavioral Inventory Rating Scales (BIRS) (Von Brock & Elliott, 1987) for each student under each type of instructional procedures, and to complete a survey on her opinions and attitudes toward both types of instruction.

Overall, students' test scores were significantly higher under mnemonic instructional conditions on chapter tests as well as class grades. In fact, the students' class grades went from D+ to B using the mnemonic instruction. Additionally, the teacher reported that the mnemonic instructional procedures were more appropriate to the students' needs than the traditional instruction. She felt students enjoyed instruction more and were much more motivated to learn when she employed the mnemonic instructional procedures than when she employed the traditional procedures. She also reported that the students were more actively engagd in class discussions when she employed the mnemonic instructional procedures.

These findings extend our previous research in several ways. First, a special education teacher implemented mnemonic instruction. Second, the instruction took place in the students' regularly assigned U.S. history classes, delivered by the assigned teacher. Third, mnemonic materials using the reconstructive elaborations model had been developed for two chapters in the U.S. history content area from their adopted textbook. Fourth, the mnemonic instruction occurred over four weeks time. Finally, all results paralleled those of the previously conducted investigations.

Second U. S. History Implementation Study

The results of the first study were promising, however, several questions remained unanswered. First, in that investigation only one special education teacher implemented the instructional procedures. She reported liking the materials, but would other special education teachers have the same opinion? Second, since only two chapters of mnemonic materials were developed and used, the question of chapter difficulty was unclear. Third, students' cumulative performance was not assessed in the earlier investigation. In other words, after several units of mnemonic instruction, would LD students begin to confuse all the previously learned information and perform more poorly on a delayed cumulative examination? Fourth, in the previous investigation, the classroom teacher administered all the tests.

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Would students perform as well on the testing situation if experimenters who were "blind" to experimental condition conducted some of the testing? Finally, in the previous study, students were not questioned regarding the use of specific strategies during recall. Therefore, it was unknown whether or not students were actually relying upon the reconstructive elaborations for retrieving the information. In order to attempt to extend the ecological validity of the model and to answer the above questions, the second research implementation study was undertaken.

In this investigation, we (Mastropieri & Scruggs, 1988) added two chapters of mnemonic materials to the U.S. history content described above. Mnemonic materials were therefore developed for the Roaring Twenties and World War II, in addition to World War I and the Depression. We trained three special education teachers in a different inner city school to use both types of materials, and set up a counterbalanced design. In one classroom, the teacher implemented mnemonic instruction for World War I, then traditional instruction for the Roaring Twenties, mnemonic instruction for the Depression, and traditional instruction for World War II. In a second classroom, the reverse order of treatments were delivered by a different teacher. In that classroom, traditional instruction was presented for World War I and the Depression, while mnemonic instruction was delivered for the Roaring Twenties and World War II. In a third classroom, another teacher delivered mnemonic instruction for the first three chapters, and traditional instruction for the final chapter. While in the fourth classroom, traditional instruction was implemented for the first three chapters, and mnemonic instruction for the final chapter. With this type of within-subjects design, we could control for several potential internal validity threats, including attrition. Additionally, in the present design two classrooms always received mnemonic instruction, while two received traditional instruction, so the question of chapter difficulty could be examined.

As in the previous investigation, instruction for each chapter occurred over a two-week period. Following each chapter, students were administered multiple choice tests covering the content taught. Additionally, teachers were observed throughout the implementation project and given feedback regarding the level of their fidelity of implementation. At the end of the eight weeks of instruction all students were given a delayed cumulative recall test that sampled content from World War I through World War II by project staff who were unaware of experimental condition. All students were also questioned regarding the strategies they used to answer the items, and given a consumer satisfaction survey regarding the mnemonic instruction. Teachers were also asked to complete the BIRS for all of their students on both traditional and mnemonic instruction, and to complete a consumer satisfaction interview.

The results of this investigation replicated the findings of the earlier investigation. When students were instructed under mnemonic procedures,

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their performance was consistently and significantly higher. This finding was true even for their performance in the delayed recall test after eight weeks, which covered content from all four units of instruction. Students also reported using the strategies to retrieve their responses on the delayed recall test, and their successful retrieval of strategies was significantly related to their recall scores. Students also reported enjoying mnemonic instruction more than traditional instruction, and learning more when teachers used those procedures. In other words, students were attributing their success to the use of mnemonic instructional procedures.

Teachers reported enjoying the mnemonic materials and thinking that such instructional procedures were more appropriate for LD students than the currently employed traditional instruction, or other procedures of which they were currently aware. Teachers reported that the strategies facilitated the learning of the targeted information better than other instructional procedures. Teachers also reported that their students appeared more "motivated" to learn and participated in class under mnemonic instructional procedures. We also found that there was no apparent confusion with the mnemonic strategies on the eight-week delayed recall test. Not surprisingly, we also found no spontaneous transfer on the part of students during traditional instruction. In other words, after as much as six weeks of mnemonic instruction, students did not generate any mnemonic strategies independently.

Elementary Level Social Studies Study

A third research implementation study was undertaken to replicate and extend the results of the two U.S. history studies (Mastropieri & Scruggs, 1989). First, we wanted to determine whether or not the reconstructive elaborations model could be adapted to state and local history materials. Second, we were interested in determining whether elementary aged special education students could benefit from mnemonic instruction. Third, we wanted additional information from teachers and students regarding the efficacy of mnemonic instruction.

We selected chapters from the adopted state history text on natural resources and transportation, and developed two sets of materials as in the previous investigation. This time, however, our target population was an elementary and middle school aged group of LD and MiMh learners. Three special education teachers were trained in both sets of instructional procedures, and each teacher implemented two instructional groups. One group received mnemonic instruction first, while the other group received traditional instruction first, for the natural resources information, and the instructional procedures were reversed for the second chapter. This within-subjects design again allowed us to control for order effects, teacher effects, chapter difficulty, and attrition. Instruction occurred over several weeks and teachers were monitored by project staff and given feedback regarding the fidelity of treatment implementation.

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The results again paralleled those found in the previous investigations. Elementary aged LD and MiMh students learned significantly more content when their teachers used mnemonic instruction than when they employed traditional instructional procedures. This finding held for both the immediate and delayed recall tests. Again, teachers and students reported enjoying the mnemonic instruction, and requested additional mnemonic materials for other content area classes.

Taken together, the results of the social studies investigations extended previous studies substantially. First, the ecological validity of the model of reconstructive elaborations was considerably advanced. Second, social studies content from adopted textbooks was adapted to incorporate the use of specific mnemonic instructional strategies. Third, long-term investigations using mnemonic instruction were implemented in schools by regularly assigned special education teachers. Fourth, statistically significant performance increases were found for immediate and long-term retention whenever mnemonic instruction was implemented. Fifth, both teachers and students reported liking the mnemonic instruction.

Science Investigations

Although the investigations in the social studies area were very successful, several questions remained. Would the model of reconstructive elaborations also work in the science content area? Science content typically contains more abstract concepts and tends to be more conceptually laden than social studies content. Although Mastropieri, Scruggs, and Fulk (in press) successfully taught abstract science concepts using acoustic reconstructions, the materials for that investigation consisted of lists of vocabulary terms, rather than materials adapted from a specific textbook. Very little work to date had examined the issue of concept teaching in the context of entire curricular area, such as science. Additionally, mnemonic materials had typically been developed by researchers, not teachers. Consequently, the following questions remained: (a) Could teachers analyze their own curricular areas in science, and develop mnemonic materials to facilitate instruction? (b) If materials were developed by teachers and implemented by them, would the findings parallel results of previous investigations? (c) Could the model of reconstructive elaborations be applied to science content area as successfully as it was with social studies curriculum? (d) Could special education students be trained to generate these strategies, rather than have teachers supply them? Investigations intended to answer the above questions are described separately below.

Teacher-made Science Materials

In the first science research implementation study several of the above questions were addressed (Mastropieri, Emerick, & Scruggs, 1988). First, a special education teacher volunteered to attempt to develop mnemonic materials in science for her special education students. Second, to assess

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the efficacy of these instructional materials and procedures as compared with her traditional instructional procedures, she implemented these mnemonic materials in a crossover design to two groups of students. Third, she assessed immediate and delayed recall, as well as consumer satisfaction of her elementary aged behaviorally disordered students.

Prior to developing the materials, this teacher participated in training designed to acquaint her with the previously conducted mnemonic investigations, as well as procedures designed to assist her with the development of the materials (e.g., Mastropieri, 1988; Mastropieri & Scruggs, 1989a). She selected the students' regularly assigned textbook in science as the content area in which her students were experiencing the most difficulty, and proceeded to develop mnemonic materials for several of those chapters. First, she identified the most important concepts in each chapter. Next, she generated reconstructive elaborations for each identified piece of information. Because all of the targeted information was totally unfamiliar to her students, she developed "acoustic" reconstructions for each unit. She relied totally upon available resources, and since the services of an artist were unavailable, she drew "stick figures" as line drawings, and utilized cut-outs from magazines whenever possible. For example, to develop the mnemonic illustration for the word "herbivore," she used the acoustically similar word "herd" and used a picture from a magazine of a "herd of animals eating grass" to teach that herbivores are animals that eat only plants. She also developed specific instructional procedures to teach students in both mnemonic and control conditions. After the science instruction, students were tested immediately following each lesson, and with delay intervals of one day, three days, and one week.

The results of this investigation paralleled and extended the previous investigations in that under mnemonic instructional conditions, students' performance significantly outperformed their performance in control instruction. Interestingly, students' performance decreased from the high 70's to the 40's in the control condition over a week, while their performance maintained in the 90's for the mnemonic condition, over the same delay interval. Students also reported enjoying the mnemonic materials. The teacher reported enjoying using the mnemonic materials, even though she reported that it was very difficult and very time consuming to develop them.

This investigation added several important findings to the accumulating evidence surrounding mnemonic instruction. First, a teacher successfully developed her own mnemonic materials to accompany the adopted textbook materials. Second, she implemented this instruction over two weeks of school in a counterbalanced experimental design. Third, her elementary aged behaviorally disordered students' performance was significantly higher under mnemonic conditions on both immediate and delayed recall tests. Finally, both teacher and students reported a preference for mnemonic materials.

Second Science Research Implementation

The first science study offered some positive findings, but left additional unanswered questions. First, because only acoustic reconstructions were employed, the issue of applications of the reconstructive elaborations models was not assessed in the Mastropieri, Emerick, and Scruggs (1988) study. Second, the implementation period lasted only approximately two weeks in the above study, and the question remained of longer-term implementation. Third, the question of student-generated mnemonic elaborations remained untested. Fourth, little attributional retraining had been conducted with mnemonic strategy instruction. Scruggs and Mastropieri's (in press) investigation was proposed to address some of these remaining questions.

In this study, science content from the adopted textbooks was adapted using the reconstructive elaborations model. Two chapters covering life science and two chapters covering the earth's history and geology were adapted using specific acoustic, symbolic, and mimetic reconstructions. It was found that the science content could successfully be adapted via the reconstructive elaborations model. For example, many of the terms introduced were unfamiliar to the target population, and those terms were reconstructed into acoustically similar, easily pictured, familiar terms, and then shown in interactive elaborations with the to-be-associated information. An example of one acoustic reconstructions that was made included teaching the meaning of "extinct." The word was unfamiliar to the target population, whereas the acoustically similar word "stink" was. Stink was shown interacting in an elaboration, for example, by depicting dead dinosaurs starting to stink, with someone saying: "These dinosaurs sure stink, that's because they are extinct!"

Concepts such as warm-blooded and cold-blooded were reconstructed symbolically, by presenting animals who were sweating while in a summer scene (warm-blooded), or wearing scarves in a cold winter-like scene (cold-blooded). Mimetic reconstructions were employed whenever the target information was considered totally familiar and concrete—for example, in learning the attributes associated with earthworms (they have many hearts, are roundworms, and live in the earth). Earthworms were pictured in an interactive elaboration containing a round worm with many hearts who was living in the earth. All the important content fit into the reconstructive framework and materials were developed accordingly. Similarly, parallel materials that identified the important information, but did not provide any strategic information were prepared for the control condition. Additionally, all students had practice activities designed to accompany the appropriate set of instructional materials and extra practice at learning the target information.

The target population was middle school learning disabled and mildly mentally handicapped youngsters who were receiving science instruction from their regularly assigned special education teachers. A crossover de-

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sign was implemented in which each of two self-contained special education classrooms received mnemonic and traditional instruction for the various units. Additionally, three phases were implemented in this design. The first phase was the training phase, during which time classrooms received either mnemonic for one chapter or traditional instruction for another. The second phase was referred to as the maintenance phase. During this phase each group received mnemonic instruction on another chapter. The third and final phase was referred to as the generalization training phase. During this phase, students were taught to generalize the strategies during their class for another new chapter of science content.

During the generalization phase, teachers identified the important information for students, but then prompted and elicited strategies from the class as a whole. For example, instead of providing the strategy for remembering that the earth's core is made of iron and nickel, teachers said something like the following: "We know that the earth's core is made of iron and nickel now. But we need to have a good way to remember that information. Remember how we used the strategies and pictures to help us learn and remember information last week? Let's try to come up with our own strategies for this information. What might be a good way to think of "core"? Then the teachers wrote all of the brainstormed ideas from the students on the blackboard. Students elicited responses like: core sounds like door, ore, cord, or apple core reminds me of core. Following that, teachers said: "We need to select the best one for us as a class to use," and proceeded to select the one that seemed optimal for the class. In the case of the present example, one class used "door," while the other class used "apple core." Teachers then said that they would draw a good interactive illustration like the ones they had used last week. Teachers drew pictures and then asked students to draw good interactive pictures on the study booklets, just like the ones they had provided in previous lessons. The resulting pictures contained either "doors with nickel and iron on them" or "apple cores made out of nickels and irons." Teachers provided students with feedback regarding their illustrations and asked students to label their drawings. Ample time was provided for students to draw and review their strategies. Additionally, all classes were videotaped for examination of specific verbal interactions that occurred throughout the instructional sessions.

Testing was completed at several times throughout this study. First, students' recall was assessed following the instruction of the two chapters that were taught either mnemonically or traditionally. Second, students were tested immediately following the week of mnemonic instruction. Students were also tested at the end of the generalization unit, and at that time given a surprised delayed recall test on all information covered to date. Students were always questioned regarding the specific strategies that they used to retrieve responses, and they were questioned regarding their preference

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for all three types of instruction that had occurred: provision of mnemonic strategies, generation of mnemonic strategies, and traditional instruction.

The results of the training phase replicated all previous investigations in that mnemonic instruction resulted in statistically higher performance for both classrooms, on both the immediate recall test and the delayed recall measure. During the maintenance phase of mnemonic instruction only, both classrooms maintained high levels of performance. During the generalization phase, the mean recall performances were slightly lower than the mean performances of mnemonic instruction delivered by the classroom teachers. However, this time, only one-third the amount of content was covered during the same amount of instructional time, as when teachers presented the mnemonic strategies that were already prepared. These results indicate that although students as a group could effectively generate their own "reconstructive elaborations," they proceeded significantly slower throughout the content than when the pace was held constant by teachers. Results from the student survey were mixed. Students were asked what they enjoyed the most, learned the most, tried the hardest, and would use again. They were also asked to rank the three instructional procedures accordingly. Mnemonic instruction (where teachers supplied the materials) was reported as the instructional condition enjoyed the most by 68% of the sample, followed by generalization training by 26% of the sample. Similarly 74% and 63% of the students reported "learning the most" and "would use again" for the teacher-supplied mnemonic materials. Interestingly, 58% of the students reported trying the hardest during the generalization training, while between 21% and 26% of the students reported generalization training as the method of "learning the most," "enjoying the most," and "would use again." Students consistently reported (between 68% and 74%) that traditional instruction was not only the "least preferred method," but also one on which they "learned the least" amount of information. Perhaps even more interesting was the fact that 42% of the students reported that they had to try the least during mnemonic instruction, but still performed very well. Taken together, the results of this and the previously described research implementation studies provide some interesting evidence on the utility of mnemonic instruction as a component of instruction for special education students. First, positive and consistent academic gains have been found across content areas, across age groups, and across handicapping conditions. Second, these positive gains have been consistently maintained over delayed recall intervals. Third, students have reported liking such instruction, and in the recent initial generalization training study, some students actually preferred this method over teacher-supplied mnemonics. Fourth, teachers have reported liking the materials, and have consistently asked for additional mnemonic materials for use in their classrooms. Although results of an initial investigation demonstrate that a teacher can develop such

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materials, it was difficult and time consuming. Finally, although this generalization information is promising on one hand, the findings are negative on the other. Although these students could successfully generate, in group formats, strategies that were successful at increasing their learning, the costs were evident in the amount of time expended to complete this activity. Teachers must carefully weigh the costs associated with training for generalization versus covering content. If the objective is to teach generalization, then the amount of time necessary is adequate. If, however, the objective is to cover content, then teachers must decide how much time is allocated throughout the year and make careful decisions regarding how that time is spent. One-third the content was covered in the present investigation, and that appears to be a significant decrease in the amount of information presented to these special education students. Additional generalization studies should be undertaken to clarify this, and to determine how well individual students might be able to generate such mnemonic strategies in the content area. This work is currently being undertaken (Fulk, 1990), as well as research to test the efficacy of these procedures when implemented in mainstream settings (e.g., Mastropieri, Plummer, & Scruggs, 1989). The final section presents some background information describing the theoretical support for mnemonic instruction with learning disabled students.

Theoretical Support for Reconstructive Elaborations

It has been widely reported that learning disabled populations exhibit serious deficits in memory (see a recent volume edited by Swanson, 1987, for a review). Some researchers have argued that these memory deficits may be language based (e.g., Swanson, 1987; Vellutino & Scanlon, 1982), while other researchers have argued that these deficits occur as a result of word-finding problems (e.g., Kail & Leonard, 1986), or semantic memory problems (e.g., Baker, Ceci, & Hermann, 1987). Baker et al. posited that deficits in the structure and the process of semantic memory are related to learning problems in this population. Similarly, Ceci (1985) suggested that LD students lack purposive semantic processing, which then interferes with their ability to encode information efficiently. Ceci further argues that LD students might be helped by specific training in elaborative strategies to assist in ameliorating these deficiencies (Ceci, 1985), while Kail and Leonard have also argued that research should focus on finding effective instructional procedures. In light of these documented deficiencies, as well as the inadequacies of previous explanations of LD (see also Kavale, this volume), it seems likely that strategies that directly intervene on semantic processing would be highly beneficial.

The research cited in this chapter tends to confirm that elaborative strategies facilitate LD students' performance on school tasks for both immediate and delayed recall tests. A potential explanation as to why such strategies are so beneficial incorporates the work from psychology on elaboration learning (e.g., Jensen & Rohwer, 1963), meaningfulness and learning (e.g., Glover & Bruning, 1987), concreteness and learning (e.g., Paivio, 1971), and effective encoding of information (e.g., Underwood & Schulz, 1960). As stated earlier, it is known that effective elaborative techniques facilitate the recall of information. Moreover, it has been seen that when information is more meaningful, it is more memorable. Additionally, when information is made concrete, it is more memorable than when it is abstract. Finally, it has been seen that when information is encoded effectively, direct retrieval routes are established and thus new information is more readily recalled.

Each of these variables—elaboration, meaningfulness, concreteness, and effective encoding—contributes toward a theoretical framework for explaining why mnemonic instruction described herein facilitates the performance of LD students. The reconstructive elaboration model utilizes each variable in presenting information to LD students and seems to be ideally suited to help these students succeed on academic tasks that have high information-processing demands.

Acknowledgements. Preparation of this chapter was supported in part by grants (G008730144-89 and H029D80034) from the U.S. Department of Education, Special Education Programs. The authors thank Tom Scruggs and Bernice Wong for their feedback on an earlier version of this chapter and Cate Violanti for her assistance in the preparation of the manuscript.

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Appendix B

Fulk, B.J.M., Mastropieri, M.A., & Scruggs, T.E. (1990). Mnemonic generalization training with learning disabled adolescents. West Lafayette, IN: Purdue University, Department of Educational Studies.

Mnemonic Generalization Training With Learning Disabled Adolescents

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Running Head: Mnemonic Generalization

Abstract

This investigation was intended to determine whether intensive generalization training specific to the development of complex mnemonic strategies would facilitate learning disabled (LD) students' ability to transfer the strategy to independent use. Fifty-six LD adolescents were randomly assigned to one of three individually administered conditions: mnemonic generalization, mnemonic generalization combined with attribution training, or a rehearsal condition. One-to-one training sessions covered strategy usage across a variety of content domains, including vocabulary learning, science, and social studies. Training and assessment occurred across three phases. Phase one emphasized training in condition-specific strategies, phase two employed prompted transfer training, while phase three assessed unprompted generalization at one-day and two-week delay intervals. Recall was assessed across conditions during all three phases: training, prompted transfer, and unprompted transfer. Results revealed statistically significant recall differences favoring the mnemonic conditions on prompted transfer days two and three, and the two-week delayed unprompted transfer task. No significant differences were found between the two mnemonic instructional conditions. Implications for teachers are discussed.

Mnemonic Generalization Training With Learning Disabled Adolescents

The investigation of differences in academic performance of learning disabled (LD) and other students has received considerable attention in the literature. Research suggests that the poor performance of LD students may be due, in part, from deficits in: (a) retrieval of language-based information (e.g., Kail & Leonard, 1986), (b) employment of conscious memory strategies (e.g., Ceci, 1985), and (c) transfer of learned strategies to other appropriate contexts (e.g., Groteluschen, Borkowski, & Hale, 1990). The vast majority of published research studies have attempted to uncover the characterizations of learning disabilities by comparing the performance of LD and normal students on various tasks (e.g., see Lovitt, 1989 for a discussion). However, equally important are the types of interventions employed to instruct these LD students. Although the amount of instructional research is limited in comparison to characteristics research (Lessen et al., 1989), throughout the past decade researchers have assessed the efficacy of a variety of interventions with the goal of ameliorating those academic deficiencies (see Scruggs & Wong, 1990, for a recent volume reviewing such efforts). Some of this research has focused directly upon specific academic content areas, such as reading (e.g., Graves, 1986), mathematics (e.g., Fleischner, Nuzum, & Marzola, 1987), or writing (e.g., Graham, 1982), while other research efforts have focused on more generic strategies such as test-taking strategies (e.g. Scruggs & Mastropieri, 1986) or learning strategies (e.g., Deshler & Schumaker, 1986). This research appeared to be intended to uncover optimal instructional strategies for increasing the performance of LD students. In fact, the majority of the published research indicates that the performance of LD students does improve after systematic intervention.

Some intervention research has focused on enhancing instruction for LD students by incorporating the principles learned from research in cognitive psychology. For example, most learning theories support the notion that information that is more meaningful and more familiar to learners will be more memorable (e.g., Glover & Bruning, 1987). Additionally, research in cognitive psychology indicates that the encoding and retrieval processes associated with the presentation of information is highly correlated with the learning of that information. Aspects of meaningfulness, encoding, and retrieval of information have been investigated with LD populations using variations of the keyword mnemonic procedure (see Mastropieri & Scruggs, 1989 and Scruggs & Mastropieri, 1990 for recent reviews).

The keyword strategy is well suited to assessing the influence of meaningfulness, encoding and retrieval processes, because the keyword method is most beneficial when a nonmeaningful entity is initially presented to a learner. That nonmeaningful entity is reconstructed into a familiar, meaningful entity, and then encoded into a meaningful elaboration with the response information to facilitate retrieval. For example, to learn the unfamiliar and nonmeaningful (to most LD students) word _corsair_, meaning pirate, corsair can be reconstructed into an acoustically similar, familiar and meaningful proxy _core_, as in apple core. This reconstructed term can then be encoded more efficiently by imagining a pirate (the meaning of corsair) eating an apple _core_. Such an interactive elaboration, whether imaginal, pictorial, or verbal, facilitates later retrieval. When asked the meaning of corsair, learners first retrieve the keyword _core_, are reminded of the interactive elaboration of "_a pirate eating a core_", and can thus retrieve the appropriate response _pirate_. When assessing the efficacy of this procedure with LD students, researchers have compared adaptations of the keyword procedure with direct instruction (e.g., Mastropieri, Scruggs, & Levin, 1986), with traditional instructional procedures (e.g., Condus, Marshall, & Miller, 1986), with direct questioning procedures (e.g., Mastropieri, 1983), with visual spatial displays (e.g., Scruggs, Mastropieri, Levin, McLoone, Gaffney, & Prater, 1986), and with free study conditions (e.g., Mastropieri, Scruggs, & Levin, 1987). In all reported cases, results have statistically favored performance of students in the keyword-type conditions.

Initial applications employed vocabulary words as tasks. In minerals) could be successfully integrated and learned in one mnemonic illustration. More recently, Mastropieri, Scruggs, and Fulk (1990) used the same principles to teach LD students abstract vocabulary, rather than the previously trained concrete vocabulary. Scruggs and Mastropieri (1989) reported that U.S. History content could be adapted from textbooks using similar principles, and that when employed as instructional procedures, LD students' learning was significantly enhanced.

Mastropieri and Scruggs (1989) reported developing mnemonic instructional materials to accompany regularly assigned textbooks. The principles were also applied to the learning of a variety of content domains, including U.S. History, Indiana History, Social Studies, Earth History, Earth Science, and Life Science. They further reported that regularly assigned teachers had successfully implemented these procedures in their classrooms with their LD students over extended time periods, and that LD students' performance was significantly enhanced when instructed using those mnemonic principles (e.g., Mastropieri & Scruggs 1988; 1989; Scruggs & Mastropieri, 1989; in press).

This classroom application research augmented the earlier laboratory investigations in several ways (see Mastropieri & Fulk, 1990, for a recent review). First, these studies provided evidence that the principles of meaningfulness, effective encoding and retrieval, underlying the keyword method could be modified and applied to larger content area domains. Second, the developed materials had been implemented by regularly assigned special and regular education teachers, who along with their students, reported enjoying mnemonic instruction. Third, students' initial and delayed recall was consistently and significantly enhanced whenever mnemonic instructional procedures were employed. Fourth, students had been able to increase their class grades from "D"s to "B"s. And finally, no obvious confusion or interference had occurred among the numerous interactive mnemonic images that students had learned.

Unfortunately, however, there had been no evidence of spontaneous transfer of strategy usage on the part of any of the LD students involved in these investigations. Earlier attempts at specific training for generalization had been successful (Mastropieri, Scruggs, Levin, Gaffney, & McLoone, 1985; McLoone, Scruggs, Mastropieri, & Zucker, 1986); however, those attempts were limited to the learning of concrete (English and Italian) vocabulary words with relatively "obvious" keywords (bugsha = bug; barca = bark). More recently, Scruggs and Mastropieri (in press) implemented specific generalization training within a classroom implementation study. This generalization training package also included an attribution training component (in which successful responses were attributed to successful strategy use and effort) and was taught to the class as a group. Under structured classroom presentations, students successfully generated "class" mnemonic strategies for important information, and drew their own interactive illustrations. Although students did learn the information under such "group transfer" training conditions, they covered little more than one third the amount of content as they had when teachers supplied all the necessary mnemonic strategic information.

Accumulating evidence has been positive regarding the utility of mnemonic instructional procedures when supplied by teachers to LD students. However, several important questions remained unanswered. First, would individual transfer training in the mnemonic procedures result in better overall transfer to a variety of content areas? Second, what is the importance of attribution training within mnemonic generalization training? Research literature has provided equivocal results regarding the helpfulness of attribution components. And finally, previous investigations either employed only one type of strategic information (e.g., only vocabulary learning), or instructed students in a single content domain (e.g., science or social studies). Would students learn to transfer the strategy better if they were instructed to transfer the strategies across a variety of content areas? In other words, would teaching more "general case" rules (e.g., Stokes & Baer, 1977) result in greater transfer? The present investigation was designed to address those questions.

Method

Subjects and Design

Fifty-six LD students from a small midwestern city and from surrounding county school districts were randomly assigned to one of the three experimental conditions: mnemonic generalization, mnemonic generalization plus attribution training, or rehearsal. All students were classified as LD following referral and assessment procedures, including the recommendations of case conference committees as mandated by state and federal legislation. Indiana State Rule S-1 guidelines for classifying students as LD had been followed, as well as local LD identification criteria including evidence of a significant discrepancy between ability and achievement as well as chronic failure in the classroom. Subsequent to parental permission, the final sample included 40 males and 16 females (19 sixth, 18 seventh, and 19 eighth graders) who had been classified LD and placed in LD classrooms for a mean of 4.7 years (*SD* = 1.8 years), and were presently receiving special education services for an average of 30% of their school day. All students had been reported to be experiencing difficulty in their content area classes. Students' mean Full Scale IQ as measured by the Weschler Intelligence Scale for Children - Revised (WISC-R) was 96.2 (*SD* = 9.9). The mean verbal IQ score was 94.0 (*SD* = 10.0) and the mean performance IQ score was 100 (*SD* = 12.0). Students' mean age was 13 years 10 months (*SD* = 13.0 months). Additional subject information by experimental condition is in Table 1.

Materials

Training materials were developed from mnemonic materials employed in previous investigations with LD students, and included information relevant to a variety of content areas, including vocabulary, social studies and science. Condition-specific experimenter scripts were written and employed to maintain standardization of treatment and instructional time across students and conditions. Manila envelopes contained training materials for each phase and session of treatment. Phase one was the first day training session, phase two included two additional days of prompted transfer training sessions, and phase three was the assessment of unprompted generalization for delay intervals of one day and two weeks. Materials specific to each phase are described separately below.

Phase one. Items for phase one (one training day) consisted of 12 (two practice and ten target) items presented individually on 8 1/2" by 11" cards. Across conditions, cards contained the target word, the definition, and an illustration centered within a lined box. Sample items included: vituperation, meaning scolding; expiry, meaning coming to an end; and stolen, a trailing branch which takes root.

Phase two. Items for phase two (two training days), consisted of ten items presented individually on 8 1/2" by 11" student booklets. Each booklet contained 10 pages and each page contained the target word, response information, and prompts, which differed by condition, for strategy use. Sample items included: dogbane is a tropical plant; Patrick Henry spoke against the Stamp Act; and petrified wood is old wood that turned to stone.

Phase three. Items for the unprompted generalization tasks at one-day and two-week delay intervals were contained in student booklets. Since these booklets were assessment booklets, they contained no condition-specific information and were identical across conditions. The first page of the booklet listed the day's content. The next 14 (one day) or 12 (two week) pages contained individual items with relevant response information with a single item presented on each page. The one-day delayed transfer task consisted of 14 pieces of information similar to that employed during the training sessions. Items included, for example: Octroi, a tax paid on goods upon entering a town; and Gavrilio Princip, a historical assassin. The two-week delayed generalization task consisted of a list of 12 presidents and associated important events for each president, e.g., that President Harding was associated with the Teapot Dome scandal. Materials specific to each condition are now described.

Mnemonic generalization training condition materials.

1. Phase one. Complete mnemonic strategies and explicit directions for using those strategies were provided. Mnemonic keyword training cards included the target word, keyword, and

response information as well as the interactive illustration of a keyword with its definition. For the vocabulary word "vituperation", for example, a viper (the keyword) was pictured scolding or speaking abusively to a someone (the definition), while the following words appeared on the top of the card: Vituperation, viper, and scolding.

Experimenter scripts explained the purpose of the strategy, described the procedures for using the strategy, and provided specific retrieval steps, (e.g., first, think of the keyword, second, think of what was happening in the picture with the keyword in it").

2. Phase two. Keyword training materials developed for Phase two contained ten stimulus words, response information, and a prompt, "Did you use the strategy?" that was printed in a lower corner of each page of the ten page booklet. During this phase, neither keywords nor interactive illustrations were provided.

In addition, two cards containing rules were employed. One card presented the three criteria for an appropriate keyword (e.g., "should sound like the new word, be a real word that you know, and be easy to draw"). Another card presented the three steps necessary to develop keyword memory strategies: first, choose a keyword; second, think of something that the keyword and its definition can do together; and third, draw that picture.

Mnemonic generalization plus attribution condition materials.

1.Phase one. Materials used in the mnemonic generalization plus attribution condition were identical to those used in the mnemonic generalization condition with the exception of the inclusion of the attribution training component. Attribution training materials were developed after those reported by Borkowski, Weyhing, and Carr (1988) and consisted of two cartoons, two printed rule cards, and experimenter scripts. Each cartoon was on an 8 1/2" by 11" card; the first depicted a student who had experienced success on a school task while the second depicted a student who had experienced failure.

Two positive (i.e., controllable) attributional reasons for success and failure were also presented on index cards. The positive attributions were: "Two main reasons why students usually do well on school tasks are these: 1) because they know a good way to remember important information, and 2) because they try hard as they use that method". The positive attribution for failure card displayed this message, "Two main reasons why students usually don't do well on school tasks are these: 1) because they don't know a good way to remember important information, and 2) because they don't try hard."

2. Phase two. The attribution materials described above for phase one were reviewed during phase two (training days 2 and 3). Experimenter scripts contained models of positive attributions for success (e.g., "I tried hard to use the strategy and got the correct answer",) and for failure (e.g., "Next time

I'll try harder to use the strategy").

The strategy use prompt for this condition (i.e., "Did you try hard and use the strategy") contained an effort attribution prompt and therefore was different from the prompt for the mnemonic generalization and rehearsal conditions (i.e., "Did you use the strategy?"). In addition a miniaturized version of the "successful" student cartoon was also printed on student booklet pages.

Rehearsal condition materials.

1. Phase one. Materials for this condition paralleled those used in the two mnemonic conditions and consisted of experimenter scripts, rule cards and cards containing the word, its definition, and a representational illustration of the word. For example, the card for "vituperation" depicted a person telling another person, "Don't speak so abusively to me", with the words "vituperation" and "scolding" along the top. The directions provided explicit instruction on how to use a rehearsal strategy effectively.

2. Phase two. These materials included a rule card, script, and student booklet. The printed card contained these steps: "1) repeat the word, 2) study the picture of the answer information, and 3) say the word and definition together". This card was introduced on Day 2 and reviewed on Day 3.

Student booklet pages were identical to those described for the mnemonic generalization condition. In addition, identical dependent measures were employed across conditions and are described in the following section.

Dependent Measures

The following dependent measures were employed in this investigation: (a) attribution assessments, (b) production and identification recall measures, and (c) strategy reports. All items were read aloud to students and responses were recorded verbatim by the investigator.

Attributions assessment. A pre- and post-intervention attribution assessment was developed to parallel a measure constructed by Krause (1983) to measure effort attributions. This measure consisted of 16 hypothetical situations (eight success and eight failure) common to school children. For example, one item was "Suppose the teacher asked some students to read parts aloud in a school program. She did not ask you. Why would this happen? Was it effort, ability, task difficulty, or luck?" Students were instructed to choose the first and second most important reasons for each occurrence.

Recall measures. The first daily recall measure consisted of production items (e.g., what does vituperation mean?). The second recall measure retested each content item in an identification (i.e., matching) format.

Strategy reports. Strategy reports were also employed each day of the investigation. Questions were as follows for each production item: (e.g., How did you remember what vituperation meant?).

Procedure

This section describes procedures common to all conditions for each of the five 25-minute sessions of this investigation, according to phase. Following this description of common procedures, condition specific procedures are described.

All conditions.

1. Phase one: Day 1 Students entered a quiet room adjacent to their classrooms, were stratified by grade level and randomly assigned to one of three treatment conditions. First, the experimenter introduced herself and explained the purpose of the sessions. Second, the attribution pretest was administered. Third, students were: informed they would be learning new vocabulary with a special memory method and that they should try hard for a quiz would be given following the instructional session. Fourth, two practice items were presented, according to condition, followed by a practice quiz containing both production and identification recall questions. Fifth, ten target items were taught, according to experimental condition. Following that, a one-minute "filler" task (in which students were asked to write down their grade, teacher, and other information) was given, followed by untimed administration of recall measures and strategy reports. Finally, students were thanked for their time, asked not to discuss the study procedures with anyone, and returned to class.

2. Phase two: Days 2 and 3. Phase two sessions first reviewed relevant strategy steps. Next, the purpose of the generalization training was presented (e.g., "to practice the memory/study strategies for independent use in all your classes)." Third, explicit instruction and questioning regarding the retrieval process were incorporated within the day's presentation. For example, students were asked, "What is the second step to our 'good memory' strategy?" However, as the generalization training proceeded, experimenter explanations and cuing were faded, until, finally, students were prompted to employ the trained strategy independently on the last two items.

Students were reminded when the strategy was appropriate (e.g., any time you need to remember two or more pieces of information together). Students were also asked to name classes that required memory strategies. Following recall and strategy measures, students were thanked for their time, reminded not to talk to peers about the procedures, and returned to class.

3. Phase three: Generalization testing. First, students were given lists of new content and directed to study them with "the method that would best help them prepare" for the quiz that would follow. Second, the experimenter read the complete list of target information, and offered to provide additional pronunciation or reading help, when necessary. Third, students were asked to study for a ten-minute interval. Following a one-minute filler activity (e.g., writing name, address, and school

information), recall measures were administered. In addition, on the two week delayed generalization test, the attribution posttest was administered. Phase three procedures did not differ across experimental conditions.

Mnemonic generalization condition.

1. Phase one. Following completion of the attribution pretest, students were told they would be learning a special memory strategy. Next, the keyword strategy was described using two practice items, and strategy feedback was given following each practice item. Students were told, for example,

> To remember that vituperation means scolding or speaking abusively to someone, these are the steps to take. First we have a keyword for 'vituperation' which is 'viper.' Viper is a good keyword because it sounds like vituperation and is easy to picture. Next we have picture of the keyword and its definition doing something together. In this case, we have a picture of a man saying to the viper, 'Don't speak so abusively to me.' To recall what vituperation means, first, think first of the keyword and second, to what was happening in the picture.

Each of the target mnemonic illustrations was presented for 30 seconds while the experimenter described the keywords and interactive illustrations. Following administration of recall and strategy measures, students were informed that during the next session they would learn to create keyword memory strategies independently.

2. Phase two. Students were reminded of the purpose of the session and were guided through the following steps using the printed cards described above: generate a keyword, think of an interaction involving both keyword and response information, and draw that picture. For example, to remember that *dogbane* is a type of tropical plant, students were prompted to generate a concrete, acoustically similar keyword (e.g., "dog"), and then to draw a picture in which a dog and a plant were interacting (e.g., a picture of a dog eating a plant). The experimenter provided review, guided practice, and prompting, as necessary. Relevant feedback was provided for each step. Each session concluded with recall and strategy measures as described above.

Mnemonic generalization plus attribution condition. The mnemonic training component was identical to that described for the mnemonic generalization condition, except that attribution training procedures were included as described below.

1. Phase one. Attribution training procedures proceeded as follows. First, the importance of attributing success and failure to controllable causes, particularly to effort, was explained through the use of the cartoons and printed cards described within the materials section. Second, the experimenter modeled both successful and unsuccessful instances of recall while employing mnemonic retrieval steps. After each instance, the relationship of effort to the outcome was

emphasized with a positive attributional message. Following a successful recall attempt, for example, the experimenter said, "I used the strategy, tried hard and remembered the correct answer." In contrast, after modeling an unsuccessful recall attempt, the experimenter said, "I didn't remember the correct answer. Next time, I will try harder to use each step of the strategy." The previously missed item was then corrected and success attributed to effortful strategy deployment. Following each subject's correct recall, the experimenter attributed successful performance to effortful strategy use (e.g., "Do you know why you recalled the answer? You used the steps to the strategy, tried hard, and answered correctly".

2. Phase two. There were four components of the attributional training in this phase. First, sessions began with a short review of the importance of positive attributions on academic tasks. Second, the experimenter modeled appropriate attributional verbalizations such as the following. "When I use the strategy to remember an answer correctly, I say this to myself; I am trying hard and using the strategy and doing well. Now, you say it. " Third, students were prompted to verbalize positive attributional messages (e.g., "What should you tell yourself when you do/do not recall the correct answer?"). Fourth, students were given combined strategy attributional feedback for all learning successes (e.g., "You tried hard and used the strategy and you remembered the correct answer").

Rehearsal condition.

1. Phase one. During this session, students were directed through an active rehearsal strategy that included the following steps: First, the experimenter pronounced the words and students were asked to repeat them. Second, representational pictures were presented for thirty seconds each while students were questioned regarding the word and definition. Third, the students were instructed to rehearse the words as well as the definitions. The students were also instructed to utilize retrieval steps as follows. "First, think of the word, second, the picture, and finally the answer information that you rehearsed."

2. Phase two. Phase two sessions began with a review of the rehearsal procedure. Second, students were guided to apply the steps to each content item with explicit explanations, prompting, and feedback of the rehearsal strategy. Prompts were faded until students were asked to employ the strategy independently for the last two content items. Strategy feedback was delivered (e.g.,"you rehearsed the word and the answer and that helped you to recall the correct answer)."

Scoring

All measures were scored by the investigator as well as by two trained university students who were blind to students' experimental condition. All discrepancies in scoring were discussed until 100% agreement was reached.

One point was awarded for each correctly answered question. For the production tests, one-half point was awarded for partially correct, but incomplete answers. Strategy reports were scored as: 0 = no strategy use, 1 = rehearsal or rote, 2 = non-keyword association (e.g., 'both lago and lake started with *l*s), 3 = incomplete keyword (i.e., missing one necessary element of either keyword or interaction), or 4 = effective keyword (i.e., containing both keyword and interaction).

Attribution assessments were scored with the following scoring procedure. Students' first and second choice attribution responses were coded according to the following: luck = 1, teacher help = 2, task difficulty = 3, ability = 4, and effort = 5. Next, first and second choice responses were summed separately to yield frequency scores and percentages for each response choice.

Results

Means and standard deviations for identification measures are in Table 2 and production recall measures are in Table 3. Data for each test were entered into three condition (mnemonic generalization, mnemonic generalization plus attribution, rehearsal) by three grade level (six, seven, and eight) analysis of covariance (ANCOVA), using Verbal IQ as a covariate. Grade level was used as a blocking variable only (Kirk, 1982), and was not of primary interest to the research questions. In some cases, cell variance was somewhat constrained; nevertheless, re-analysis using nonparametric tests revealed results parallel to those reported here. Although analysis was conducted on raw scores, mean test scores by condition are reported as percentage correct to facilitate interpretation. Mean square error scores are provided in raw score units.

Phase one. On the first day training test, students correctly identified 87% (mnemonic generalization), 83% (mnemonic generalization plus attribution) and 76% (rehearsal) of the information studied in phase one (MSe = 3.44), and correctly produced 71%, 69%, and 68% of the information for the same three conditions, respectively (MSe = 3.44). Although the students in both mnemonic conditions outperformed the rehearsal condition students, the differences were not statistically significant, $F(2,46) = 2.33$, $p = .11$; and $F(2,46) = .27$, $p = .76$ for identification and production tests, respectively. No significant grade or interaction effects were observed (all $ps > .34$).

Phase two. In the first prompted transfer test, students correctly identified 97% (mnemonic generalization), 89% (mnemonic generalization plus attribution) and 82% (rehearsal) of the information studied (MSe = 2.40), and correctly produced 86%, 82%, and 66% of the information for the same three conditions, respectively (MSe = 4.36). Statistically significant differences were obtained on both identification and production tests, $F(2,46) = 4.17$, $p = .02$; and $F(2,46) = 4.93$, $p = .01$, respectively. Student-Neuman-Keuls (SNK) post-hoc tests indicated that students in the mnemonic generalization condition had significantly ($p < .05$) outperformed students in the rehearsal condition on the identification test, while both mnemonic conditions significantly outperformed the rehearsal condition on the production test. No significant grade or interaction effects were observed (all ps >.27).

In the second prompted transfer test, students correctly identified 97% (mnemonic generalization), 95% (mnemonic generalization plus attribution) and 71% (rehearsal) of the information studied (MSe = 2.29), and correctly produced 81%, 87%, and 64% of the information for the same three conditions, respectively (MSe = 2.73). Statistically significant differences were obtained on both identification and production tests, $F(2,46) = 16.46$, $p = .00$; and $F(2,46) = 8.91$, $p = .00$, respectively. SNK post-hoc tests indicated that students in the mnemonic generalization condition and the mnemonic generalization plus attribution condition had significantly outperformed students in the rehearsal condition on both identification and production tests. A significant grade by condition interaction was found on the production test, $F(4,46) = 2.74$, $p = .04$. No other significant grade or interaction effects were observed (all ps >.20).

Phase three. In the one-day delayed unprompted transfer task, students correctly identified 63% (mnemonic generalization), 66% (mnemonic generalization plus attribution) and 69% (rehearsal) of the information studied (MSe = 12.25), and correctly produced 48%, 54%, and 57% of the information for the same three conditions, respectively (MSe = 10.37). No statistically significant differences were obtained on either identification or production tests, $F(2,46) = .29$, $p = .75$; and $F(2,46) = .70$, $p = .50$, respectively. No significant grade or interaction effects were observed (all ps >.08).

In the two-week delayed unprompted transfer task, students correctly identified 63% (mnemonic generalization), 57% (mnemonic generalization plus attribution) and 38% (rehearsal) of the information studied (MSe = 12.36), and correctly produced 46%, 44%, and 30% of the information for the same three conditions, respectively (MSe = 9.69). A statistically significant difference was obtained on the identification test, $F(2,46) = 3.96$, $p = .03$; but not on the production test, $F(2,46) = 2.22$, $p = .12$. Significant main effects were also found for grade, $F(2,46) = 6.82$, $p = .00$; and $F(2,46) = 3.58$, $p = .04$, respectively, for identification and production tests. Interaction effects were not observed (both ps > .31). SNK post-hoc tests indicated that students in the mnemonic generalization condition and the mnemonic generalization plus attribution condition had significantly outperformed students in the rehearsal condition on the identification test.

Strategy Data

Strategy data from each phase of the study are in Tables 2 and 3. Percentages of strategies reported by students, as well as percent correct for those items are listed. As can be seen, students in the two mnemonic conditions reported using the instructed strategy in either complete or partially complete forms at over 80% during phase one, over 90% during phase two, at least 50% of the time during the unprompted transfer days. In all cases, reported strategy use was significantly correlated with production scores (all rs = .35 to .68, all ps < .01).

Attribution Measure

No significant difference was observed among conditions on repeated measures ANOVA conducted on attribution pretest and posttest scores, $F(1, 53) = .01$, $p = .91$.

Discussion

LD students who were trained to create mnemonic keyword strategies recalled more information than those trained to employ rehearsal strategies on the prompted transfer tasks (i.e., Days 2 and 3), and the two week delayed unprompted transfer task (identification test) of this investigation. No significant recall differences resulted among conditions on a one-day delayed unprompted transfer task. Finally, no significant group differences were found between students who did and did not receive attribution training.

That performance differences were not found on training day

1 contrasts sharply with numerous previous mnemonic investigations in which mnemonically instructed students substantially outperformed students in various comparison conditions. However, this training day did not include instruction of keywords prior to presentation of mnemonic illustrations, as done in previous investigations. Keywords were individually introduced as the training progressed, to help familiarize students with the rationale for keyword selection preliminary to generalization training. However, since the mnemonic conditions descriptively outperformed the rehearsal condition and the corresponding statistical test approached significance (p = .11), it is possible that the failure to reject the null hypothesis in this case represents a Type II error. Regardless of the adequacy of the statistical test, however, the obtained effect sizes were substantially smaller than those of previous investigations.

Results of second and third training day testing indicated that LD students guided and prompted to use keyword mnemonic strategies consistently outperformed LD students guided and prompted to use rehearsal strategies. Subsequent to one session with imposed keyword strategies, LD students effectively created their own keywords and interactive illustrations with minimal assistance, prompting, and training time, across multiple content areas including English vocabulary, Italian vocabulary, science, and social studies information.

Although differences were not observed on a one-day delayed transfer task, students trained to generalize mnemonic strategies performed significantly higher on the two-week delayed identification transfer task. The lack of performance differences on the one-day delayed transfer task may have been affected by the short time (ten minutes) allocated for study, which was apparently inadequate for at least eight students in the two mnemonic conditions who were unable to complete all 14 content items. Since mnemonic condition students were required to develop strategies and draw mnemonic pictures as well as study the content, the amount of time allocated may have been insufficient. In contrast, rehearsal condition students were able to devote the entire time to studying. The superior performance of mnemonic condition students on the two-week delayed transfer task, using a somewhat shorter list, provides evidence that LD students need not be totally dependent on teacher provided mnemonics, but in fact can be taught to independently develop these strategies.

Strategy data revealed that rehearsal generalization condition students had reported employing rehearsal strategies more frequently than mnemonic generalization condition students reported employing complete mnemonic strategies. Although the rehearsal strategy was apparently easier to transfer to novel learning situations, the strategy itself was less effective compared with complete or even partially complete subject-generated mnemonic strategies.

Another important finding from the strategy report data is the number of items on the transfer tasks for which mnemonic condition students reported not using any strategy. This was apparently due to the fact that many students, when unable to invent a mnemonic strategy, simply skipped that item. Future investigations might include instruction in strategies to use when keywords do not immediately come to mind. Such investigations may find even greater performance advantages for mnemonically instructed students than those reported here.

Finally, no differences in performance were observed as a result of effort or strategy attributions. Since attribution training did not result in higher scores on the transfer measures, it appears that the training of the mechanics of strategy transfer was of greater importance than attribution training in facilitating strategy generalization. Previous research has suggested that LD students who have received mnemonic instruction are well aware of the powerful facilitative effects of these strategies (e.g., Scruggs & Mastropieri, in press; Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1987). If this is true, direct teaching of attributions may be less necessary for mnemonic strategies than it is for strategies whose effects are more subtle or more indirect. Although mnemonic strategies may be difficult for LD students to transfer, due to the demands placed on word knowledge, insight, and creativity, metacognitive awareness of the power of mnemonic strategies may compensate in part for this difficulty.

Further research is necessary to uncover the most important components of inducing mnemonic strategy transfer. Since the present investigation was relatively limited in training days, classroom-based research could assess the efficacy of more intensive, long-term training procedures. Nevertheless, the results of the present investigation, taken together with the Scruggs and Mastropieri (in press) classroom based investigation, suggest that LD students can be trained to transfer mnemonic strategies to a variety of content areas, and that their academic performance is enhanced when they use the strategies that they have developed.

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Table 1

Subject Demographic Data by Condition*

Mnemonic Generalization	Mnemonic Attribution	Directed Rehearsal
Sex	Sex	Sex
Numbers:	Numbers:	Numbers:
Male 12	Male 14	Male 14
Female 07	Female 05	Female 04
Ethnic:	Ethnic:	Ethnic:
90% White	100% White	100% White
10% Black		
IQ Verbal:	IQ Verbal:	IQ Verbal:
Mean 94.9	Mean 91.7	Mean 96.4
(*SD*) 8.1	(*SD*) 7.8	(*SD*) 13.3
IQ Perf.:	IQ Perf.:	IQ Perf.:
Mean 102.6	Mean 101.4	Mean 96.0
(*SD*) 13.5	(*SD*) 11.0	(*SD*) 12.2
Reading achievement:	Reading achievement:	Reading achievement:
Mean 78.8	Mean 74.0	Mean 84.0
(*SD*) 9.8	(*SD*) 8.2	(*SD*) 18.0
Math achievement:	Math achievement:	Math achievement:
Mean 81.1	Mean 79.0	Mean 81.0
(*SD*) 9.9	(*SD*) 11.0	(*SD*) 11.0

Note. *Perf. IQ = Performance IQ scores; Reading and math achievement are reported in standard scores.

Table 2

Percentages of Strategies Reported for (Percents of Correct Production Responses) Phases 1 and 2

	Mnemonic Generalization	Mnemonic Attribution	Directed Rehearsal
Phase 1 (Day 1)			
Prior Knowledge	01 (100)	00 (00)	04 (50)
No Strategy	13 (52)	13 (56)	16 (45)
Rehearsal	01 (50)	01 (66)	80 (74)
Non-mnemonic association	00 (00)	00 (00)	00 (00)
Incomplete keyword	25 (72)	24 (75)	00 (00)
Complete keyword	61 (75)	61 (73)	00 (00)
Phase 2 (Day 2)			
Prior Knowledge	01 (100)	00 (67)	06 (64)
No Strategy	03 (50)	03 (100)	04 (50)
Rehearsal	01 (70)	01 (50)	88 (68)
Non-mnemonic association	00 (00)	00 (00)	01 (00)
Incomplete keyword	05 (70)	04 (100)	00 (00)
Complete keyword	91 (88)	92 (86)	00 (00)
Phase 2 (Day 3)			
Prior Knowledge	00 (00)	01 (100)	06 (100)
No Strategy	03 (60)	02 (100)	06 (27)
Rehearsal	01 (100)	00 (00)	86 (68)
Non-mnemonic association	01 (100)	01 (100)	02 (100)
Incomplete keyword	13 (83)	12 (82)	00 (00)
Complete keyword	84 (90)	85 (90)	00 (00)

Note. Mnemonic Attribution= Mnemonic Generalization plus Attribution Condition.

Table 3

Percentages of Strategies Reported for (Percents of Correct Production Responses) on Phase 3: One-Day and Two-Week Delayed Tasks

	Mnemonic Generalization	Mnemonic Attribution	Directed Rehearsal
One-Day Delay			
Prior Knowledge	05 (67)	02 (25)	09 (82)
No Strategy	32 (38)	32 (36)	16 (17)
Rehearsal	05 (58)	05 (64)	71 (68)
Non-mnemonic association	03 (83)	02 (67)	14 (78)
Incomplete keyword	24 (40)	24 (63)	00 (00)
Complete keyword	33 (62)	35 (73)	00 (00)
Two-Week Delay			
Prior Knowledge	00 (00)	00 (00)	02 (50)
No Strategy	30 (38)	37 (19)	22 (17)
Rehearsal	05 (43)	05 (00)	71 (39)
Non-mnemonic association	03 (100)	02 (67)	05 (50)
Incomplete keyword	24 (52)	24 (46)	00 (00)
Complete keyword	33 (70)	35 (73)	00 (00)

Note. Mnemonic Attribution= Mnemonic Generalization plus Attribution Condition

Appendix C

Mastropieri, M.A. (1988). Using the keyword method. _Teaching Exceptional Children_, _20_(2), 4-8.

Using THE KEYE METHOD

CORRECTION

The title of the article by Margo A. Mastropieri that appeared in the Winter 1988 issue of *TEACHING Exceptional Children* was incorrect. The correct title is "Using the Keyword Method."

Margo A. Mastropieri

Research in vocabulary instruction has shown that a variety of methods are effective for assisting students in learning the meanings of new words (see Stahl & Fairbanks, 1986, for recent reviews). Recently Levin and his colleagues (Levin et al. 1984; Mastropieri, Scruggs, Levin, Gaffney, & McLoone, 1985; Pressley, Levin, & Delaney, 1983; Scruggs, Mastropieri, & Levin, 1985) have found the keyword method (Atkinson, 1975) superior for teaching the meanings of new vocabulary words. This article describes the keyword strategy so that special education teachers can adapt it to their instructional uses. (See Mastropieri & Scruggs, 1987, for further information.)

The keyword method has been validated through a number of research studies with learning disabled, mentally retarded, gifted, and typical students (Mastropieri, Scruggs, & Levin 1985a; Mastropieri, Scruggs, & Levin, 1985b; Mastropieri, Scruggs, & Levin, in press; Scruggs, Mastropieri, & Levin, 1985; Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1987). This article describes what these strategies are and how they can be used to improve vocabulary instruction.

The Keyword Method

The keyword method is a mnemonic (memory-enhancing) technique used to increase the initial learning and retention of facts and fact systems of the kind often encountered in schools. The method incorporates both auditory and visual cues to enhance meaningfulness of the information to be learned and to promote strong associations between questions and answers. This method also relies strongly upon visual imagery—a procedure that has been found to be effective with mildly handicapped learners (McLoone, Scruggs, Mastropieri, & Zucker, 1986). The method can be taught to students using the steps of recoding, relating, and retrieving.

Recoding

Recoding involves changing a vocabulary word into a word that sounds similar and is easy to picture. This new word is usually referred to as the *keyword*. For example, to learn the meaning of the word *apex*, first *recode*

it to a word that sounds similar to "apex" and is easily pictured. In this case *ape* would be a good keyword, since "ape" sounds like the first syllable of "apex" and is easy to picture. Most elementary-level mildly handicapped learners are familiar with the concept of "ape." If learners were unfamiliar with that concept, then "ape" would be a poor choice.

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Relating

Relating means integrating the newly formed keyword with its definition either by imagining (or having the student imagine) a picture of the keyword and its definition doing something together or by creating a sentence in which the keyword and its definition are doing something together. Research results (Levin, 1981) have demonstrated that recall will be stronger when the keyword and definition are interacting. For example, since *apex* means *highest point* and *apex* was recoded to the keyword *ape*, the relating step involves generating an interactive picture of an *ape doing something* with a *highest point*.

A good interactive image is a picture of an ape sitting *on* the highest point of a rock. In this case, the ape and the highest point are interacting, or doing something together. If the ape were simply sitting *next to* the highest point, the keyword and its definition would not be interacting. That type of picture or image would not facilitate learning as much as an interactive illustration.

Retrieving

Retrieving is recalling the definition after being presented with the original vocabulary word. The retrieval process involves several simple steps. When learners are asked to supply the definition of the vocabulary word, first they are told to think of the keyword for that word. Remember that the keyword sounds similar and is easily pictured so that most learners can retrieve it easily. Second, the learners are told to think back to the picture (image or sentence) that the keyword was in and remember what was happening in that picture. Third, they are told to state the definition. Once the keyword and the interactive image have been retrieved, the definition is recalled easily, since the keyword is interacting with the definition. Suppose, for example, a learner is asked, "What does *apex* mean?"

First the learner thinks of the keyword *ape*. Second, he or she recalls that the *ape* was sitting on the *highest point* of a rock. And finally, the learner states that "apex" means "highest point." A sample scripted lesson for instructing students in the steps necessary to use the keyword method follows.

Students draw a picture for the keyword "flagon" to aid them in recall.

- Today I'm going to help you learn some new vocabulary words. I want you to try hard, because at the end of our session I will give you a quiz to see how well you remember the meanings of the words. I am going to teach you how to use a special method for remembering.
- The first thing I am going to teach you is a keyword for each new vocabulary word. A keyword is a little word that sounds like part of the new vocabulary word, and it is easy to picture. For example, the keyword for "raven" is "raisin." What is the keyword for "raven"? Good. Now I"m going to show you a picture that will help you remember the meaning of "raven." (Show illustration, Figure 1A.) The keyword for "raven" is "raisin." A "raven" is a blackbird. Remember this picture of a blackbird eating raisins. Remember this picture of what? . . . And raven means what? . . .
- (Remove illustration.) Now, when I ask you the meaning of a word, you need to do the following things. For example, I might say, "What does 'raven' mean?" or "What is a raven?" First you should think back to the keyword for "raven." That is . . . Good. Next, you need to think back to the picture that has the raisins in it, and then you need to think about what else was happening in that picture, which was . . . Good! A blackbird was eating raisins. Therefore, we know that a "raven" is a "blackbird." Let's try the next example.
- The keyword for "marmalade" is "mama." What is the keyword for "marmalade"? Good. Now I'm going to show you a picture that will help you remember the meaning of "marmalade." (Show illustration, Figure 1B.) The keyword for "marmalade" is "mama." "Marmalade" is jam. Remember this picture of a mama spreading jam on bread. Remember this picture of what? . . . And marmalade means what? . . .
- (Remove illustration.) If I asked, "What does 'marmalade' mean?" or "What is 'marmalade'?" First, what is the keyword for "marmalade"? Good! Next you need to think back to the picture that has the mama on it and then think back to what else was happening in that picture. Good. "Marmalade" means jam because the keyword for "marmalade" is "mama" and the picture has a mama spreading jam on bread. Good! Do you have any questions? (Adapted from Mastropieri & Scruggs, 1987.)

Experience has shown that learning disabled, mentally retarded, and behaviorally disordered learners are typically successful at using this method after one or two practice examples have been provided.

Sometimes learners have benefited from initial practice with the words and their respective keywords. For example, prior to instructing students on vocabulary words and their definitions such as flagon—canteen, derelict—tramp, oculist—eye doctor, gulch—canyon, and duct—pipe, it has proved beneficial to practice studying each new vocabulary word and its respective keyword. For these words, teachers might use the following keywords:

Flagon	Flag
Derelict	Dairy
Oculist	Octopus
Gulch	Sea gull
Duct	Duck

(Adapted from Taylor, 1981.)

Note that all of the keywords sound similar and are easily pictured. When the students can remember the keywords easily (usually after going through the list once or twice), the teacher can add the definition and interactive image step. The following "interacting image" phrases would be appropriate for the words used in the example:

1. Flagon (flag): A *flag* with a *canteen* on it.
2. Derelict (dairy): A *tramp* milking a *dairy* cow.
3. Oculist (octopus): An *octopus* having his eyes examined by *an eye doctor*.
4. Gulch (sea gull): A *sea gull* flying in a *canyon*.
5. Duct (duck): A *duck* walking inside a large *pipe*.

Again, note that the keywords and their respective definitions are interacting. These sentences could be described verbally and students asked to repeat them and imagine a picture of them, or sample illustrations depicting the interactions could be shown. Following this, students could be required to practice the retrieval steps. Typically, a little bit of practice will result in very high acquisition rates. Once the words are acquired, students will be better able to use the new words in context.

Scientific Word Parts

Using the keyword method, Viet, Scruggs, and Mastropieri (1986) taught middle-school-age learning disabled students scientific word parts and then required them to use those word parts in understanding more complex words. For example, students were taught the following word parts and definitions:

Ornith	Bird
Thero	Wild animal
Paleo	Old
Sauro	Lizard
Bronto	Thunder

Then they were to figure out the meanings of the following "dinosaur" terms:

1. Ornithopoda ("bird footed")
2. Theropoda ("wild animal footed")
3. Paleopoda ("old foot")
4. Brontosaurus ("thunder lizard")
5. Pterosaurus ("winged lizard")

To accomplish this, they were taught keywords and shown illustrations depicting the interactions in Table 1.

After the students had learned the individual word parts, they were able to figure out the meanings of the combined whole words. Many times mildly handicapped students are expected to learn lists of scientific words for their mainstream classes. In cases where the same regular education curriculum is covered annually, special educators could keep a list of good keywords and interactive images for critical vocabulary. Over time, a number of materials could be developed, practiced, and saved.

Table 1

KEYWORD ILLUSTRATIONS

Word part	*Keyword*	*Interactive illustration*
1. Orinth	Oar	*Bird* carrying an *oar*
2. Thero	Thermos	*Wild animal* drinking out of a *thermos*
3. Paleo	Pail	*Old people* carrying *pails*
4. Sauro	Saw	A *lizard sawing*
5. Bronto	Bronco	A *bronco* (horse) bucking in *thunder*

Other Considerations

Up to this point, the discussion has dealt with how special educators can develop keyword techniques for increasing their special education students' initial acquisition of new vocabulary. This section addresses fluency building, application, and generalization of vocabulary words learned using the keyword method.

Fluency Building and Application

It is not enough to have students simply acquire new vocabulary words. Once they begin to learn the new words, they need to be able to use them spontaneously. In other words, the new vocabulary needs to become part of their working vocabularies.

After the keyword method has assisted students in acquiring the new vocabulary, teachers must focus instruction on requiring them to use the new vocabulary frequently in a variety of contexts. Such practice will enhance their ability to retrieve the words more rapidly and enable them to use the words in speaking and writing. Typically, this type of instruction relies on the use of practice exercises that require students to use the new words in sentences or prompts them to use the words in their oral communications.

For instance, teachers might design instructional worksheets that require learners to use the newly acquired definitions. They would first use identification formats requiring learners to select the correct response, and follow these with worksheets involving production formats. Samples of each format are given here.

Identification Format

Directions: Select the appropriate word from list A and write it in the correct sentence.

List A	1. Apex	3. Derelict
	2. Gulch	4. Garb

Sentences

1. Another word for highest point is (apex).
2. Someone who wanders from place to place with no job could be called a tramp or a (derelict).
3. (Gulch) means the same as canyon.
4. Clothing is occasionally referred to as (garb).

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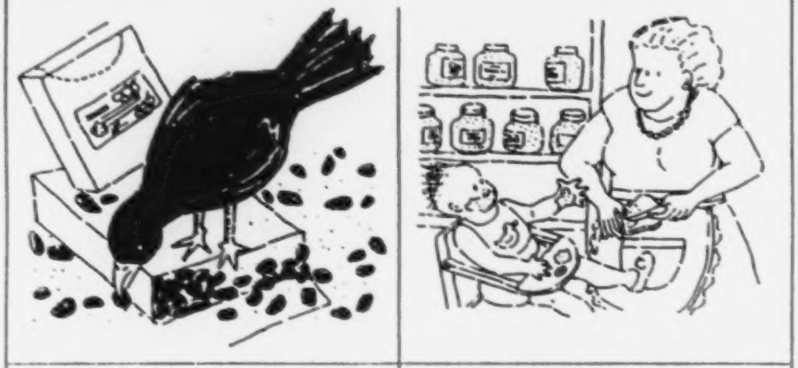
Figure 1

MNEMONIC ILLUSTRATIONS



(A) RAVEN (Raisin) Black Bird (B) MARMALADE (Mama) Jam

Production Format A

Directions: Write synonyms for the following words:

1. Highest point 3. Canyon
2. Tramp 4. Clothing

Production Format B

Directions: Write two paragraphs that include this week's vocabulary words. (e.g., "The derelict's garb was dirty and torn in several places.")

During this stage of instruction, teachers should reinforce learners for accurate use of the new vocabulary in both written and oral work. In fact, teachers might want to arrange opportunities for learners to use the new words during an oral language period. (See Mastropieri & Scruggs, 1987, for additional practice ideas.)

Generalization

It might seem that this type of strategy is too complex for special education students to use independently. However, research has demonstrated that when learning disabled students have been instructed in the keyword vocabulary method they have been able to transfer the strategy to independent learning of similar lists of words (McLoone, Scruggs, Mastropieri, & Zucker, 1986). Although these results are based on a single study, the data are encouraging. During this investigation, learning disabled students worked in a one-to-one situation and were provided practice and feedback on their performance with the keyword method. In this structured situation, learning disabled students were able to generate their own keywords and interactive images, which enabled them to retrieve the new definitions accurately.

Conclusions

Recent research has shown that the keyword method can be effective in helping mildly handicapped students acquire new vocabulary words. This method also has been adapted to help learning disabled students recall learning single facts (Mastropieri, Scruggs, & Levin, 1985b); classification systems of science facts (Mastropieri, Scruggs, McLoone, & Levin, 1985); multiple science facts (Scruggs, Mastropieri, Levin, & Gaffney, 1985; Scruggs, Mastropieri, Levin, McLoone, Gaffney, & Prater, 1985); and facts from prose passages (Mastropieri, Scruggs, & Levin, in press; Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1987).

In any system of instruction, it is important to remember that the procedures used should match the instructional objectives. Finally, as in all instruction, formative evaluation procedures should be conducted frequently to evaluate teacher and student performance and progress (see Mastropieri & Scruggs, 1987). The information thus gathered can be used to make ivnstructional decisionvs.

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Appendix D

Mastropieri, M.A., Emerick, K., & Scruggs, T.E. (1988). Mnemonic instruction of science concepts. Behavioral Disorders, 14, 48-56.

Mnemonic Instruction of Science Concepts

Margo A. Mastropieri, Kim Emerick, and Thomas E. Scruggs

ABSTRACT

Previous research has documented the severe academic deficiencies of behaviorally disordered students, but little is known regarding optimal strategies for teaching content area information to such students. The purpose of the present investigation was to determine whether mnemonic instruction, previously found effective with other mildly handicapped learners, would be effective with behaviorally disordered students. In addition, this study was intended to extend previous research by evaluating the efficacy of teacher implemented mnemonic instruction, delivered in small instructional groups using adapted classroom curriculum materials over several weeks of implementation time. Behaviorally disordered students were given two units of instruction in science concepts in a crossover design, with each student receiving both mnemonic and traditional instruction. Results indicated that students' learning was significantly improved when instructed mnemonically. Furthermore, mnemonic instruction resulted in very high levels of retention, whereas traditional instruction resulted in significant decreases in delayed recall. Additionally, students reported high levels of satisfaction with the mnemonic materials and procedures. Implications for academic instruction of behaviorally disordered students are provided.

Research has consistently demonstrated severe academic deficits in students characterized as emotionally disturbed or behaviorally disordered. Mastropieri, Jenkins, and Scruggs (1985) reviewed a wide range of studies investigating academic characteristics of behaviorally disordered students, and reported that all authors had concluded that the academic deficits of this population are severe and persistent. These deficits were found whether the children had been characterized as autistic, psychotic, aggressive, withdrawn, delinquent, or incarcerated; and whether students ranged in age from primary grades to senior high school age. Although socialization deficits are the primary presenting characteristics of behaviorally disordered students, effective instructional strategies for improving academic functioning are clearly needed (Mastropieri, Jenkins, & Scruggs, 1985).

Scruggs and Mastropieri (1986) evaluated the academic achievement of 1480 behaviorally disordered and learning disabled elementary grade students, and reported that both groups were similarly deficient, but that behaviorally disordered students were, in several instances, significantly lower than their learning disabled counterparts. An analysis of subtest score performance revealed that behaviorally disordered students performed lowest overall in science achievement.

Several instructional procedures have been recommended to help correct academic deficits of behaviorally disordered students. Generally, these strategies are intended to intervene upon the attentional or motivational deficits found in this population which are thought to negatively influence academic learning (e.g., Kauffman, 1985). Kerr and Nelson (1983) have reviewed research which supported the use of token economies in managing academic behaviors (see also Hewett, 1968). By means of periodic provision of redeemable tokens for acceptable levels of *on-task* behavior or task completion, token economies have been demonstrated to be effective in maintaining attention and effort toward academic tasks. In most cases, however, token economies have been effective in increasing engagement on independent seatwork on worksheets. These tasks have been described by Mastropieri and Scruggs (1987) as "practice activities," helpful in facilitating fluency of learned responses. However, these activities may be less effective in introducing new

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Partial support for this project was provided by Grant No. G008739144-88 from the U.S. Department of Education, awarded to the first and third authors and Purdue University. The authors thank Catey Violanti for her assistance in the preparation of this manuscript.

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concepts or procedures. Smith and Lovitt (1976) demonstrated that reinforcement alone was insufficient in inducing academic learning when students had not been provided with necessary academic strategies.

Teacher presentation rates have also been thought to have an impact on attentional and motivational variables. Carnine (1976) provided evidence that levels of responding and attention increased in two low-achieving, primary age students, when instruction was overt and fast-paced. Such positive, fast-paced teacher-led presentations could be expected to increase acquisition of new content by increasing levels of academic engagement and motivation. However, the instructional strategy frequently employed in such presentations — rehearsal — has not always been found to be the optimal learning strategy for acquiring new associative information (Jensen & Rohwer, 1963; Rohwer, Raines, Eoff, & Wagner, 1977; Scruggs & Cohn, 1983; Scruggs & Mastropieri, 1985; Scruggs, Mastropieri, Levin, & Gaffney, 1985). Other learning strategies may also be shown to positively influence the learning of behaviorally disordered students, but to date little research has been done in this area.

Mastropieri, Scruggs, and Levin (1985) reported that the use of mnemonic (memory-enhancing) instruction had been shown to be effective in increasing initial learning in some mildly handicapped populations. Essentially, mnemonic instructional procedures are intended to provide a retrieval link between stimulus and response information, thus facilitating later recall. For instance, to learn that an *omnivore* is an animal that eats both plants and animals, the stimulus term is first reconstructed to a concrete, more familiar, acoustically similar proxy, or *keyword*. In this case, "omelette" is a good keyword for omnivore, because it sounds like omnivore and is easily pictured. The reconstructed keyword, then, is shown in an interactive picture with its response, in this case, a picture of someone eating an omelette that has both plants and animals in it.

Mnemonic pictures such as the one described above reinforce learning of the concept by picturing one concrete instance of the concept. They also reinforce the association of the concept with its name by showing the concept interacting with an acoustically similar keyword. Mnemonic techniques have been employed with mildly handicapped students, and have been consistently found to be far more effective than alternative instructional procedures based on fast-paced rehearsal, free study, or use of organizational pictures (Mastropieri, Scruggs, & Levin, 1987).

In spite of the initial successes of mnemonic instruction, several research questions remain to be addressed. First, virtually all research on mnemonic techniques to date employed experimental materials which were not necessarily part of the classroom curriculum. It would be of importance to know the extent to which existing classroom materials could be adapted to mnemonic instruction. Second, most mnemonic materials to date have been developed by researchers. The extent to which teachers could be trained to develop their own mnemonic materials has not been systematically investigated. Third, with few exceptions (e.g., Condus, Marshall, & Miller, 1986; Veit, Scruggs, & Mastropieri, 1986), research on mnemonic techniques has focused upon specific strategies applied to specific types of content in individual lessons. The extent to which mnemonic instruction is effective over longer instructional units has been infrequently studied. Finally, and most relevant to the present investigation, with the exception of one short-time pilot investigation (Scruggs & Mastropieri, 1982), virtually no research has addressed the extent to which students with behavioral disorders can benefit from mnemonic instruction. It could be, for instance, that specific attentional or motivational deficits of these students would prevent them from benefiting from such complex instructional strategies.

The present investigation, therefore, was intended to address all the above issues by evaluating the effectiveness of teacher-developed and teacher-presented mnemonic instructional strategies, based upon classroom curriculum, in facilitating the learning and later retention of behaviorally disordered students.

The content area chosen for this investigation was science concepts, as the teacher had identified this content area as particularly difficult for her students, as well as the fact that previous research has indicated that knowledge of science in particular (Scruggs & Mastropieri, 1986), and information about the world in general (Reilly, Ross, & Bullock, 1980;

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Scruggs & Laufenberg, 1987) represent serious deficit areas in behaviorally disordered populations.

METHOD

Subjects

Students who were attending a separate public school setting for seriously emotionally disturbed students participated in this investigation. All students had been classified as seriously emotionally disturbed following assessment procedures completed by a school psychologist as well as recommendations from a multidisciplinary team. The classification criteria included the following definition adopted according to Indiana Rule S-1: A seriously emotionally disturbed child is a child with a severe condition exhibited over a long period of time and to a marked degree, which adversely affects educational performance and is characterized by one or more of the following: (a) inability to learn which cannot be explained by intellectual, sensory, or health factors; (b) an inability to build or maintain satisfactory interpersonal relationships with peers and teachers; (c) an inappropriate type(s) of behavior or feeling under normal circumstances; (d) a general pervasive mood of unhappiness or depression; (e) a tendency to develop physical symptoms or fears associated with personal or school problems. Additionally, these students were characterized by their teacher as exhibiting severe frustration with academic tasks, severe disruptive behaviors, and low self-esteem.

All students attended the same self-contained classroom that was taught by two certified special education teachers. The teacher who developed the materials and implemented the instructional procedures had 5 years of teaching experience and was in the process of completing the requirements for a Master of Science degree in special education. All academic areas including reading, language, math, spelling, science, social studies, and social skills were taught by these two personnel.

The 7 boys and 1 girl who participated in this investigation ranged in age from 7 to 11 with a mean age of 9 years 3 months (*SD* = 11.14 months), and ranged in grade level assignments from one to four. Intellectual quotients ranged from 80 to 109 with the average WISC-R IQ equal to 88.13 (*SD* = 8.8). All students were performing well below average on academic achievement measures. Average percentile scores according to the Wide Range Achievement Test were 15.86 (*SD* = 11.73) for reading, 19.00 (*SD* = 22.20) for math, and 15.71 (*SD* = 20.82) for spelling. Typical target behaviors for this group of students included increasing positive social relationships with peers and adults, increasing attention to academic tasks, increasing compliance with teacher directions, and decreasing disruptive and aggressive verbal and physical behaviors. Behavior was managed through administration of positive and negative contingencies including praise, stickers, feedback, and several levels of response contingent timeout.

Teacher Training and Material Development

First, the teacher participated in a 3-hour presentation on mnemonics instruction. The presentation reviewed previously conducted research on mnemonic instruction (e.g., Mastropieri, Scruggs, & Levin, 1985) and included a description of "how to develop" the materials. The teacher also was required to read several published papers on the topics (e.g., Mastropieri, 1988). Following this, the teacher selected science as the target content area. Materials were then developed from the regularly assigned science textbook that was adopted by the local school corporation (Mallinson, Mallinson, Smallwood, & Valentino, 1987). Two separate chapters were selected for use in this investigation. One chapter covered information on food chains, while the other covered information on invertebrate animals. Seven vocabulary concepts were selected from each chapter, and two comparable sets of materials were developed for each set of target concepts: one for mnemonic teaching, and one for traditional teaching. Each is described separately below.

Mnemonic condition. Keywords and interactive illustrations were developed for each vocabulary concept and placed on 8½ by 11 in. paper for each targeted word. For example, to teach that herbivore means an animal that eats only plants, the keyword *herd* was selected and written next to the word *herbivore*. The definition of herbivore was written next to the keyword. Then, the interactive illustration of a herd of animals eating plants was depicted below the labels. All mnemonic words and interactive illustrations were similarly depicted. Materials were developed using combinations of stick figures, simple line drawings, and pictures taken from magazines.

Additionally, teacher-made directions were written that consisted of the instructions to be used with the students while presenting the mnemonic information. The instructions included: (a) teaching the students that the keyword sounded like the target word, but was easily pictured, (b) learning to think of the picture that contained the keyword and the definition doing something together, and (c) being able to retrieve the appropriate information when asked.

Traditional condition. All target words and their definitions were written on separate index cards. For example, the word herbivore and its definition of animals that eat only plants were written on a card, while on another card the target word was written on one side and the appropriate definition was written on the reverse side.

Teacher-made directions including presentation instructions for the students were also written. For example, these directions included (a) presenting the words and their definitions on index cards to the students, (b) having students verbally rehearse the words and their definitions with the teacher, and (c) having students practice recalling the appropriate definitions on their own.

Student surveys. A survey of consumer satisfaction for the materials was constructed which was administered to all students after the final delayed recall test. The survey included six items, and assessed the students perceptions of the instructional materials, and their relative value in promoting learning, including such items as "did you like using the (mnemonic) pictures"? and "did the pictures help you to learn more"?

PROCEDURE

Both Conditions

Each student received mnemonic instruction for one chapter and traditional instruction for the other chapter. Students were divided into two groups for instructional purposes. Groups were equated for ability, age, achievement level, and size. Each group of 4 students was instructed using the mnemonic-keyword method for one chapter, and traditional instruction for the other chapter. However, the chapters were counterbalanced, such that group one learned the chapter on food chains mnemonically, while group two learned that chapter via traditional instruction. The second week, group one learned the chapter on invertebrate animals via traditional instruction, while group two was taught that chapter mnemonically. This counterbalancing of materials allowed for the experimental control of relative chapter difficulty. Each of the 8 students received both types of instruction, and served as her or his control for analysis purposes.

Science lessons were taught to each group in a separate room from the remainder of the class to ensure separation of treatments. Science instruction was held in the afternoons on three consecutive days. The first two instructional lessons lasted 20 minutes, and the third lesson lasted 30 minutes. All lessons incorporated the "effective teacher" variables of teacher presentation, direct questioning of relevant information, corrective feedback, and guided and independent practice (Mastropieri & Scruggs, 1987). Both group and individual questioning and responding were employed in each condition. Individual tests were given to students immediately following each lesson, as well as at 1-day, 3-day, and 1-week intervals. For each test, the teacher verbally asked the student to define each vocabulary concept which had been covered up to that time. The teacher recorded student responses verbatim. Answers were scored as correct or incorrect, and a percentage correct was computed for each test. Each day's instructional procedures are described below.

Day 1. During the first lesson, three or four vocabulary concepts were introduced and practiced. At the end of the first lesson students were given individually-administered tests on their recall of the information from the lesson.

Day 2. In the morning on day 2, students were given another test on their recall of the information taught during the first lesson. During the afternoon of day 2, students were instructed in the remaining three or four vocabulary concepts for that chapter using procedures parallel to those used during Day 1. Again after the lesson, students were individually administered a recall test of the content covered only during day 2.

Day 3. In the morning on day 3, students were administered a test on the words covered during day 2's instruction. During the afternoon of day 3 students were administered a cumulative recall test for all information covered during the first 2 days of instruction. Students were then given opportunities to draw pictures of the information from the chapter. The directions for drawing relevant pictures of newly learned information were the same for both conditions. Completed pictures were displayed in the classroom until the day before the delayed recall test.

One week delayed recall. One week after completion of each unit, students were individually administered a final recall test of their knowledge of the unit. As in the daily testing procedures, the teacher verbally asked students to define each vocabulary concept and recorded the students' responses verbatim.

Mnemonic Condition

During the mnemonic condition lessons, each new word was introduced, followed by the keyword and presentation of the teacher-made interactive pictures. Throughout the lesson, each mnemonic strategy was explained to and reviewed with the students. For example, to teach the meaning of *herbivore*, students were first told the definition, *animals that eat only plants*. Next, students were taught the keyword for herbivore (herd), and told that the keyword was to be used to help remember the meaning of herbivore. Students were then shown a picture of animals in a herd, eating only plants. They were told when asked the meaning of herbivore, to think of the keyword, herd, think back to the picture of the herd of animals, remember that they were eating only plants, and provide the answer, "animals that eat only plants." Words were individually presented and practiced until all words for that day were covered thoroughly, followed by a review of all of the day's words at the end of the lesson.

Traditional Condition

During the traditional condition lessons, students were shown the index cards containing the words and their definitions. As in the mnemonic condition, words were individually presented and practiced followed by a cumulative review at the end of the lesson. The teacher did not make reference to keywords in the traditional condition. Students were prompted to rehearse the meanings by repeating them initially and then recalling them on their own. Both group and individual rehearsing, recalling, and feedback were conducted throughout the lesson.

Both Conditions

Each instructional condition, mnemonic and traditional, lasted an equivalent amount of time (30 minutes on days 1 and 2 and 20 minutes on day 3). Since some of the instruction in the mnemonic condition was devoted to keyword learning, students in the traditional condition actually received more time practicing the target information.

RESULTS

Academic Outcomes

Across chapters (which had been counterbalanced) four mnemonic scores and four traditional scores were recorded for each student. Data were then entered into a two condition (mnemonic vs. traditional) by four (delay interval) analysis of variance (ANOVA) with repeated measured on both the condition and delay variables. Figure 1 graphically displays the means by condition and delay interval. Significant main effects were found on both the condition variable, $F(1,6) = 11.46$, $p = .015$, and the delay interval variable, $F(3,18 = 5.47$, $p = .008$. Across delay intervals, students scored an average of 94.5% correct in the keyword

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mnemonic condition and 58.8% correct in the traditional instruction condition (*MSe* = 1554.6). A significant effect was also found for condition by delay interval interaction, *F*(3,18) = 5.98, *p* = .005. Simple effects tests (Winer, 1971) applied to each condition revealed that recall of information learned in the traditional instruction condition significantly decreased over delay intervals, *F*(3,18) = 6.21, *p* = .004; while no overall differences were obtained across delay intervals in the keyword mnemonic condition, *F*(3,18) = 1.16, *p* = .354. This condition by delay interval interaction is displayed graphically in Figure 1.

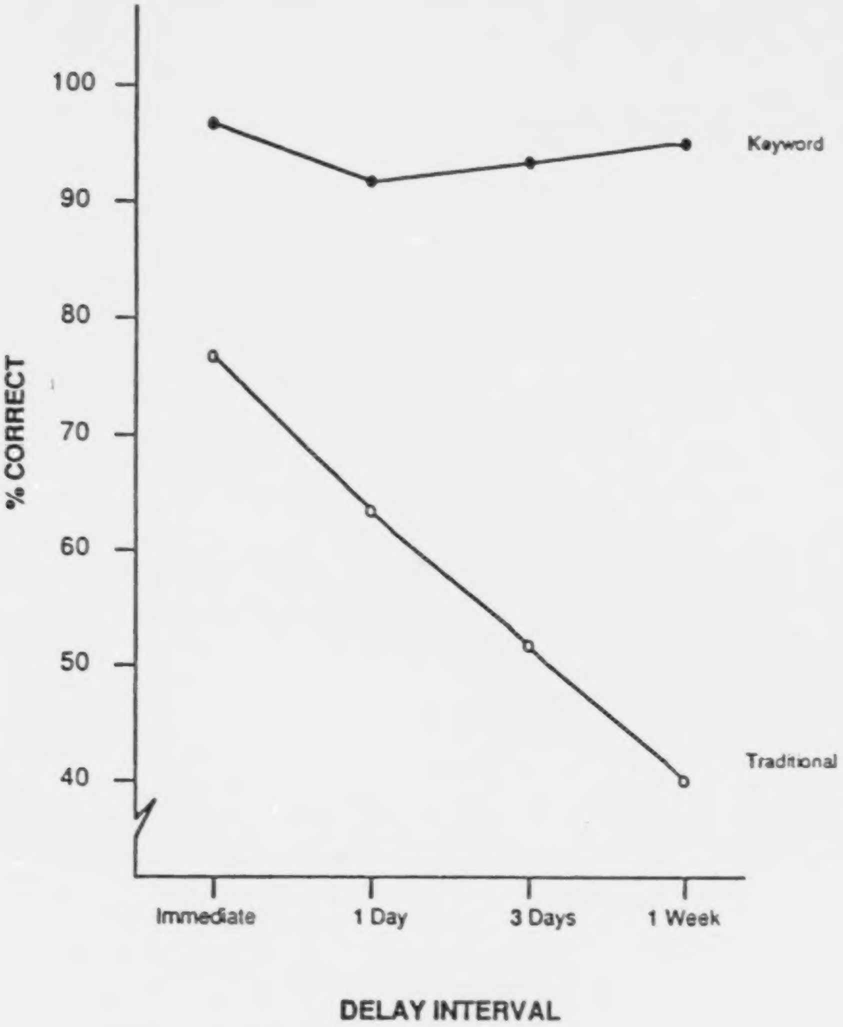

Figure 1. *Condition by delay interval interaction*

(One of the 8 subjects was dropped from the final analysis of test scores due to absences during instruction and delayed recall tests. However, this student, when he was in attendance, also learned more under mnemonic instruction, *M* [mnemonic] = 90.6 — M [traditional] = 83.0, and reported higher levels of satisfaction with the mnemonic materials, as described below.)

Consumer Surveys

Students. All students reported that they enjoyed using the mnemonic materials and that they had learned more content and got better grades when using mnemonic pictures than under traditional instruction. All students reported that they preferred mnemonic materials to traditional materials, except for one student who reported that he also liked traditional presentations because it was challenging. All students also reported that they would like to use similar mnemonic materials in other classes in school. When asked how they usually study for science tests, 2 reported that they did not know, while the remaining 6 reported vague procedures such as say the words, look at the words, or think in my head.

Teacher. The teacher reported that the mnemonic method was fun and rewarding to use. She reported that the students appeared more motivated to learn and actually appeared to enjoy learning the science concepts during the mnemonic instruction. Additionally, the teacher reported that although the initial planning and development of mnemonic materials required more *thinking* time than the preparation of the traditional materials, she felt it was worth the time since the students not only enjoyed the instruction, but also learned more content.

DISCUSSION

In the present investigation, behaviorally disordered students exhibited superior knowledge and retention of science concepts when provided with teacher-made mnemonic materials and instructional procedures. Unlike most previous mnemonic investigations, the present investigation included teacher presentations over an extended period of time. This investigation also extended previous positive findings of mnemonic instruction into instructional units involving life sciences. Of perhaps greatest importance, however, is the fact that behaviorally disordered students were seen to profit academically from extended mnemonic instruction.

Survey data suggested that the behaviorally disordered students in this investigation perceived mnemonic methods and materials as being enjoyable and beneficial to learning. That students reported enjoying tests more after mnemonic instruction is of interest in that behaviorally disordered students have previously been observed to report differentially negative attitudes toward tests (e.g., Scruggs, Mastropieri, Tolfa, & Jenkins, 1985). In addition, the students in this investigation reported an appreciation that similar materials could be expected to produce similar benefits in other content or skill areas. These findings are of interest in that students could be expected to exhibit higher levels of attending and motivation on instructional methods and materials which they reportedly enjoy and value. Attending and motivation represent areas in which behaviorally disordered students are thought to be seriously deficient (Kauffman, 1985). Future research, perhaps including larger population samples over longer time intervals, and employing different content, can help extend our knowledge in this area.

Across delay intervals, differences in learning and recall were substantial across the experimental conditions, averaging nearly 95% for mnemonic lessons and below 60% for traditional drill-and-practice lessons. It could be argued that, in the present instance, experimental condition made the difference between a grade of A and a grade of F in school learning, according to commonly-used standards.

The total instructional time was equated between conditions. Nevertheless, the complexity of the mnemonic strategy necessitated, according to the teacher, a slower overall presentation rate than that of the traditional condition, which resulted in more opportunities for responding in the traditional condition. Since faster presentation rates are generally thought to positively influence learning (Carnine, 1976), it is possible that presentation rate per se might have influenced the outcome. However, the results of this investigation indicate that the instructional condition with the *slower* presentation rate was the more effective. Additionally, results from previous experimental research indicate that mnemonically instructed students outperform control students when rate of presentation is controlled (Mastropieri, 1983), and when rate of presentation is documented but not controlled (Veit, 1986).

Several questions remain unanswered in this investigation. For example, although the teacher reported that students were more actively involved during the mnemonic instruction, no direct measures of on-task behavior were recorded. Similar reports from teachers have been obtained in more recently conducted studies (Mastropieri & Scruggs, 1988; Scruggs & Mastropieri, 1988). In addition, the present study did not formally assess fidelity of treatment implementation. However, investigations conducted since the present one have assessed fidelity of treatment implementation, and have found teacher reports are corroborated by researchers' observations (e.g., Mastropieri & Scruggs, 1988; Scruggs & Mastropieri, 1988).

Although the present results were very positive, mnemonic instruction should not be regarded as an educational panacea for behaviorally disordered or other populations. As stated earlier, a major advantage for mnemonic instruction has been seen to be in its effect on initial acquisition of academic information. Nevertheless, facilitation of levels of learning such as fluency and generalization will in many cases require additional appropriate instructional strategies (Haring, Lovitt, Eaton, & Hansen, 1978; Mastropieri & Scruggs, 1987). Rather than replacing instructional procedures previously recommended for behaviorally disordered students, mnemonic instruction presumes that many of these procedures are in place in the behaviorally disordered classroom, such as systematic enforcement of classroom rules (Kerr & Nelson, 1983), token economies and level systems (Mastropieri, Jenne, & Scruggs, 1988), and teacher-directed explicit instructional procedures (Mastropieri & Scruggs, 1987). What mnemonics can add to these procedures is a systematic retrieval route which can help insure that learners will retain what they have learned, and that they may come to regard learning as an enjoyable experience. To this extent, mnemonic instruction holds great promise as a *special* education strategy for behaviorally disordered students.

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Received 29 June 1988
Initial acceptance 15 August 1988
(Final acceptance 14 September 1988)

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Appendix E

Mastropieri, M.A., & Scruggs, T.E. (1988). Increasing content area learning of Learning Disabled Students: Research implementation. Learning Disabilities Research, 4, 17-25.

Increasing Content Area Learning of Learning Disabled Students: Research Implementation

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Learning disabled students from four classrooms were taught four chapters of U.S. history by their regularly assigned special education teachers over an 8-week period. Individual chapters were taught using either mnemonic instruction or more traditional, textbook-based instruction in a counterbalanced order, so that each classroom had a different configuration of treatment order. Students were given a chapter test at the end of each chapter, as well as a cumulative recall test at the end of the 8-week instructional period. Results indicated that students learned substantially more content when instructed mnemonically, on individual chapter tests as well as on the cumulative recall test. Furthermore, students reported favorable attitudes toward the mnemonic materials and generally attributed their relatively higher levels of performance to those materials. Teachers rated the mnemonic materials as significantly more appropriate than traditional textbook-based materials for content area instruction of learning disabled students.

Many professionals agree that learning disabled (LD) students often exhibit deficits on memory tasks (Swanson, 1987a). Furthermore, it has been suggested that memory deficits of LD students may be, in large part, language-based (Baker, Ceci, & Herrmann, 1987; Scruggs, 1988). Swanson (1987b), for example, argued that LD students, unlike nondisabled learners (NLD), do not benefit from the provision of verbal labels for unfamiliar pictorial information. Vellutino and Scanlon (1982) described research that suggested that LD students exhibit relative deficiencies in learning verbal associates; on nonverbal tasks, performance of LD students is similar to that of NLD learners. In addition, Kail and Leonard (1986) attributed the "word-finding" problems of LD readers to deficiencies in both storage and retrieval of verbal information. They argued that future research "should be based as much on the quest for instructionally relevant information as on the search for differences between learning-disabled children and their peers on tasks that are state-of-the-art but instructionally vacuous" (p. 200). Ceci (1985) maintained that LD students exhibit relative deficits on purposive, rather than automatic, semantic processing; furthermore, it was argued that LD students with semantic processing deficiencies should be taught "purposive information-processing strategies like elaborative encoding, chunking, anticipation, type 2 rehearsal, and so on" (Ceci, 1985, p. 219).

One type of elaborative learning strategy that has been successful with LD students in experimental situations is the mnemonic keyword method (Mastropieri, 1988; Scruggs, Mastropieri, & Levin, 1987). The keyword method involves reconstructing unfamiliar stimulus terms into concrete, meaningful proxies, and elaborates the transformed stimulus with the to-be-learned response information. For example, to learn that Eddie Rickenbacker was a World War I flying ace who shot down many German airplanes, the learner is first provided with a keyword for Rickenbacker. In this case, "linebacker" is a good keyword because it sounds like "Rickenbacker" and is easily pictured. A picture is then provided of the reconstructed keyword and the response in an interactive picture or image, here, a picture of a linebacker shooting down German planes over a football field. When asked, then, who Rickenbacker was, learners can think of the keyword "linebacker," think

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back to the picture of the linebacker, and describe the relevant information (that is, Rickenbacker was a flying ace who shot down German airplanes).

Keyword and related mnemonic strategies have been used to improve the recall of LD students, and the results have been highly successful. Mnemonic techniques thus far have been employed with LD students in the areas of English vocabulary (Condus, Marshall, & Miller, 1986; Mastropieri, Scruggs, & Fulk, in press; Mastropieri, Scruggs, Levin, Gaffney, & McLoone, 1985; McLoone, Scruggs, Mastropieri, & Zucker, 1986), foreign language vocabulary (McLoone et al., 1986; Veit, Scruggs, & Mastropieri, 1986), science facts (Mastropieri, 1983; Mastropieri, Scruggs, & Levin, 1987a; Scruggs, Mastropieri, Levin, & Gaffney, 1985), science classifications (Mastropieri, Scruggs, McLoone, & Levin, 1985; Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1987), and natural history (Mastropieri, Scruggs, & Levin, 1987b; Veit et al., 1986). In all these experiments, LD students taught by mnemonic instruction have outperformed students taught by a wide variety of control procedures. It has also been found that LD students were able to comprehend mnemonically elaborated information (Mastropieri, Scruggs, & Fulk, in press; Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1987; Veit et al., 1986), and benefit from extended mnemonic instruction, employing different mnemonic lessons over several days of instruction (Veit et al., 1986; for reviews, see Mastropieri, Scruggs, & Levin, 1987b; Scruggs, Mastropieri, & Levin, 1987).

In spite of the recent successes of mnemonic instruction for LD students, however, several important issues have not been addressed. One area of concern is the level of adaptability of keyword-based mnemonic instruction to actual curricular materials, rather than the experimenter-selected information used in most previously reported studies. Because the keyword method is most appropriate when stimulus information is unfamiliar and not meaningful to the learner (e.g., Rickenbacker) (Mastropieri, Scruggs, & Levin, 1985), it is important to examine the utility of the keyword method when incorporated into curriculum-based information at all levels of meaningfulness and concreteness.

Mastropieri and Scruggs (in press) have described a model of "reconstructive elaborations," in which to-be-learned content was reconstructed along the dimensions of meaningfulness (i.e., to the learner) and concreteness of the curricular information, and linked with stimulus and response information. For example, to facilitate associations when the stimulus information was meaningful and concrete (e.g., "What were conditions of World War I trenches?"), a teacher can provide representational "mimetic" pictures in which stimulus and response information are linked. For meaningful but abstract information (e.g., U.S. policy), symbolic reconstructions can be used, in which the stimulus is represented by a symbolic picture (e.g., "Uncle Sam" for "U.S. Policy") interacting with the to-be-remembered information. Finally, keyword-type "acoustic" reconstructions were used for unfamiliar information (e.g., Rickenbacker example) that relies upon familiar, concrete proxies that acoustically resemble unfamiliar information.

Scruggs and Mastropieri (in press-b) adapted a chapter from a U.S. history textbook using the model of reconstructive elaborations and taught the information to LD adolescents. Compared to controls given an equal amount of time in experimenter-directed nonmnemonic instruction, mnemonically instructed students performed better by a factor of nearly two to one and maintained this advantage over a 3-day delayed recall interval. In addition, obtained treatment magnitudes (effect sizes) increased as the information taught became successively less familiar and concrete. That is, keyword-type strategies resulted in the largest effect sizes, followed by symbolic and mimetic reconstructions, respectively. Nevertheless, statistically reliable differences were found for all types of elaborations.

The Scruggs and Mastropieri (in press-b) investigation provided important information regarding the mnemonic adaptation of curricular materials. Nevertheless, little research has been conducted involving the actual long-term implementation of mnemonic instruction of classroom curriculum. Condus et al. (1986) evaluated the effectiveness of teacher-implemented vocabulary instruction using the keyword method with LD students for 15 training sessions over a period of 5 weeks. That investigation reported that keyword mnemonic instruction resulted in superior recall over a variety of control conditions, on weekly as well as delayed tests, administered over a 10-week delay interval. No research available to date, however, has evaluated the results of teacher-implemented mnemonic instruction of content-area information employing different mnemonic techniques. Furthermore, measures of teacher or student satisfaction with mnemonic adaptations of classroom content have not previously been studied.

In this investigation, these issues were evaluated by (a) adapting four chapters from a U.S. history textbook to mnemonic instruction, (b) evaluating the effectiveness of teacher presentations of this content to LD students over an 8-week period, and (c) evaluating student and teacher reports regarding the appropriateness and effectiveness of mnemonic instruction.

METHOD

Subjects

Subjects for this investigation included 37 students in a lower SES inner-city midwestern junior high school. All students were attending regularly assigned history classes for LD students. Because of attrition over the 8-week period, subject information is reported for only the 27 students who were present for the cumulative unit test. These students included 16 seventh and 11 eighth graders, of whom 12 were Caucasian and 15 were black. Average age for the sample was 14 years, 4 months (*SD* = 9.5 months). Seventeen of the students were male. Sixty percent of the students had been placed in special education classes for at least 6 years; all students were presently attending at least four special education classes daily.

All students had been classified LD as a result of teacher referral for learning problems, assessment by a school psychologist, and concurrence by a multidisciplinary team that "learning disabled" was an appropriate characterization, based upon federal and state standards that include a persistent learning problem not explained by intellectual, sensory, or psychosocial factors. Average *Weschler Intelligence Scale for Children–Revised* (WISC–R) scores for the students for whom exact scores were available was 89.3 (*SD* = 8.7); the remaining students were characterized as functioning on the "average" (*N* = 4), "low average" (*N* = 4), or "borderline" (*N* = 1) levels. Achievement scores were taken from either the *Wide Range Achievement Test*, the *Peabody Individual Achievement Test*, or the *Woodcock-Johnson Psycho-Educational Battery*. Average reading grade equivalent score for this population was 3.0 (*SD* = .8); average math grade equivalent was 4.2 (*SD* = 1.4).

The three female teachers of the four history classes had an average of 9 years teaching experience at the junior high level (range = 4–13 years). Two of the three had advanced degrees in education while all three had LD endorsements.

Materials

Mnemonic Materials. The mnemonic materials were developed from information presented in the assigned U.S. history textbook, *Land of Liberty* (Rawls & Weeks, 1985). Approximately 20 to 30 mnemonic illustrations were developed to assist in teaching the relevant information for each of the following chapters: World War I, The Roaring Twenties, The Great Depression (the 30s), and World War II. A complete outline of each chapter was also developed. All outlines and illustrations were put on overhead transparencies.

Teacher scripts were developed to accompany the materials for each chapter. These were intended to assist teachers in describing the strategies to the students and to assist them with providing relevant guided practice during the acquisition stage of learning. Scripts included the chapter outline, descriptions of the important information to be learned, explanations of how to use the strategies, and periodic review and practice pages. A sample script, employing an acoustic reconstruction in which the keyword method was used, is given in Figure 1. Figure 2 is an exam-

FIGURE 1 Sample script using acoustic reconstruction

Woodrow Wilson was elected president in 1913. Foreign affairs became an important part of this administration. He selected William Jennings Bryan to be Secretary of State. Bryan was opposed to all wars, or a peacemaker. Someone opposed to all wars is called a pacifist. Between 1913 and 1914, Bryan negotiated 30 "cooling off" or peace treaties among the nations of the world.

[Show overhead.] To remember that Bryan was the Secretary of State who opposed all wars, think of the keyword for Bryan: lion. What is the keyword for Bryan? [Elicit responses.] Remember this picture of a lion who is a secretary at a desk saying, "Please, no fighting," to the other animals, to help you remember Bryan was the Secretary of State, who opposed all wars. Tell me what you think of when I ask who Bryan was. [Elicit responses and provide feedback.]

FIGURE 2 Sample script using symbolic reconstruction

World War I started in 1914, when countries in the Central and Allied Powers began to fight each other. What year was this, everyone? Good, 1914. In 1914, when World War I began, the American president, Woodrow Wilson, called upon all Americans not to take either side in the fight. Whose side did the United States take, at first? Good, neither side.

[Show overhead.] To remember that the United States at first did not take either side, think of Uncle Sam to remind you of the United States. In this picture, Uncle Sam is standing on a globe, saying, "It's not my fight!" while looking at Europe, where the Central Powers and Allied Powers are fighting. That means that, at first, the United States did not take either side in the war. So, what did the United States do at first when the war began? Good, they didn't take either side. And how can you remember that? Remember, though, we said *at first*. Later, the U.S. did get involved in the war, and I'm going to give you two reasons why we did.

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ple of a scripted presentation using a symbolic reconstruction to picture abstract information. Finally, Figure 3 shows a mimetic reconstruction script used to provide an elaboration between meaningful and concrete information.

Student booklets were also developed to accompany each chapter. Booklets included the first paragraph of the teacher script (describing the target information) and the labeled interactive illustration, as in the examples given.

Traditional materials. Parallel teacher scripts and student booklets were designed for the traditional condition. These materials included textual information identical to the mnemonic materials, with the exception that no mnemonic strategy information was included.

Both conditions. Both conditions also had their regular materials available to them. These included textbooks, student worksheets, and notes.

Design

Because the school that agreed to cooperate in this investigation had a high absentee rate, and because there was a desire to control for within-classroom factors, a within-subjects design was used where each of the four classrooms received both mnemonic and traditional instruction in a counterbalanced order. Each subject, therefore, served as his or her own control; consequently, classroom or teacher factors and subject attrition were not considered to be serious threats to study integrity.

Each of the four classrooms received the instructional treatments in a different configuration. Classroom 1 was presented the four chapters in order A-B-A-B, in which A represents traditional instruction and B represents mnemonic instruction. Classroom 2 was taught by a different teacher in order B-A-B-A. Classroom 3 was taught in order A-A-A-B, and classroom 4 (taught by the same teacher as classroom 3) was taught in order B-B-B-A. Within this design then, two classrooms received traditional instruction, while two received mnemonic instruction, for each given chapter. The configurations for classrooms 3 and 4 were used to evaluate, in classroom 4, the effects of three consecutive chapters of mnemonic instruction, and the effects of the three previous chapters on any spontaneous transfer to learning in the fourth chapter.

Procedures

Both conditions. Teachers were asked to use the model of effective instruction (Mastropieri & Scruggs, 1987) that incorporated the following components: (a) daily review, (b) statement of objective, (c) teacher presentation of new material, (d) guided practice, (e) independent practice, and (f) formative evaluation. First, teachers received instruction on how to implement all the instructional procedures from trained project staff. In addition, a videotape of a teacher implementing the appropriate instructional procedures was reviewed and left with the teachers for their access at any point throughout the project. All teachers were asked to keep instructional logs of dates, time, and amount of content covered throughout the investigation and were observed at regular intervals by project staff in order to assess treatment fidelity for both instructional procedures. Time was held constant across treatment conditions. Each chapter was covered over a period of 2 weeks and each class period lasted 50 minutes.

Mnemonic condition. Teachers implemented the strategies as depicted in the videotaped model. The important information was identified for the students, and then the strategy was provided to assist with the learning and recall of that information. Teachers also used their regular procedures and materials for practice activities and for formative evaluation.

Traditional condition. Procedures paralleled those in the mnemonic condition. Teachers also identified the important information and used their regular procedures and materials; however, no mnemonic strategies were provided.

FIGURE 3 Sample script using mimetic reconstruction

In 1915, the Germans, from the Central Powers, declared the waters around England a war zone. They wanted to stop the shipping of war supplies to the Allied Powers. They said they would sink any enemy ships in the area with their submarines. The English battleships could stop ships too. But the German submarines could stop enemy ships only by sinking them. If a submarine came to the surface to inspect or seize another ship, it could be blasted out of the water by the deck guns of an enemy ship. The submarines, then, stayed beneath the surface of the water, and fired torpedoes into the enemy ships.

[Show overhead.] Remember this picture of a submarine being shot by an enemy ship as it rose to the surface of the water. This will help you remember that if the German submarines came above the surface, they would be shot and sunk. Why couldn't German submarines come to the surface to stop Allied shipping?

Dependent Measures

Students were given a 20 to 30 item, group-administered multiple-choice test at the end of each chapter. Representative items are shown in Figure 4.

During these tests, teachers were available to help students. In addition, at the end of the 8 weeks of instruction, students were given an individually administered cumulative unit test read to them by examiners blind to experimental condition. This test sampled items from each of the individual chapter tests. During the administration of this measure, students were questioned on strategies they had used to retrieve the information. For the first item answered correctly in each of the four chapters, students were asked how they remembered that specific information. Student responses to strategy questioning were transcribed verbatim on the answer sheet.

In addition to the recall measures, students were asked by their teacher, at the end of the instructional unit, to complete a brief survey of their opinions of the mnemonic instructional materials and the degree to which they attributed their learning gains to these materials. Questions included (a) whether they liked using the mnemonic materials, (b) whether they thought their grades on tests improved as a result of the materials, (c) whether they would use the materials again if they had the opportunity, and (d) whether they would enjoy using similar mnemonic materials in other subjects. Teachers also took a brief survey of their opinion of the value of the mnemonic materials. Finally, to assess teachers' perceptions of the appropriateness of the instruction for addressing specific learning needs, teachers were asked to complete the *Behavioral Intervention Rating Scale* (BIRS) (Von Brock & Eliott, 1987) for both the mnemonic materials and the traditional instructional materials, for each student. Teachers were instructed to consider students' academic problem behaviors in social studies when completing the survey.

RESULTS

Recall Tests

Chapter tests. All students were given a group administered multiple choice recall test (20 to 30 items) at the end of each chapter. Scores were converted to percentages and averaged within instructional conditions, so that, for each subject completing all four tests, one mnemonic condition score and one traditional instruction score were computed. Because of the high level of absenteeism in these classrooms, four complete chapter tests were available on only 19 students. These students scored an average of 63.9% correct ($SD = 14\%$) in mnemonic conditions and 53.7% correct ($SD = 17\%$) in traditional instruction conditions. These mean scores were statistically different, as shown by a t test for correlated samples using arcsin-transformed percentage scores ($t(18) = 3.08$, $p < .01$). An analysis was also conducted on scores of subjects who had missed one or more of the chapter tests, but who nonetheless had taken tests covering content taught via both mnemonic and traditional procedures. The scores of these seven additional subjects paralleled the other scores, with means of 74.0% correct ($SD = 17.1\%$) and 49.1% ($SD = 12.4\%$), respectively, for mnemonic and traditional chapters.

Delayed recall test. At the end of the eighth week of instruction, a multiple choice recall test covering the information from the four chapters was administered individually by examiners who were blind to experimental conditions. Twenty-seven students were available for the administration of the unit test. Overall, total scores on the cumulative unit test were found to be highly predictive of combined scores from the four chapter tests for the 19 students who had been in attendance for the administration of all five tests

FIGURE 4 Sample items from chapter tests

6. William Jennings Bryan:
   (a) shot down 26 German planes.
   (b) proposed the League of Nations.
   (c) wrote the song "Over There."
   (d) was the Secretary of State who opposed all war.
8. At first, when European nations went to war, the United States:
   (a) did not take either side.
   (b) secretly aided the Central Powers.
   (c) immediately joined the Allies.
   (d) forced all Germans to leave the United States.
9. German submarines could not rise to the surface of the water to stop shipping because:
   (a) the motors could not operate above water.
   (b) submarines could not communicate with ships above water.
   (c) submarines, when above water, could be shot by the deck guns of the ship.
   (d) submarines were prevented by treaty from operating on the surface.

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(r = .840, $p < .001$). These cumulative unit tests were scored by chapter, condition, and by classroom, and are shown in Figure 5. As can be seen, in all four classrooms, students obtained higher scores under mnemonic instruction than under traditional instruction. Across individual chapters, it was found that students recalled an average of 75.6% (SD = 22.7%) of the information they were taught mnemonically and 44.0% (SD = 22.1%) of the information they were taught using traditional instruction. This difference was also statistically meaningful, as shown by a t test for correlated samples using arcsin-transformed percentage scores ($t(26) = 6.71$, $p < .001$).

Strategy Reports

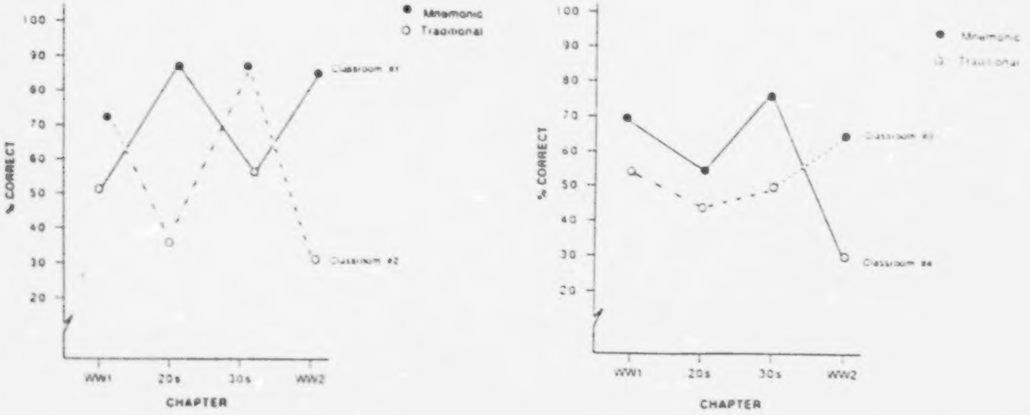
Individual strategy reports were scored for complexity of strategy used. A score of 0 was awarded for responses such as "don't know" or "guessed"; 1 point was awarded for responses that referred generally to recalling notes or teacher presentation without reference to specific strategies; 2 points were awarded for any attempt to elaborate the information or tie it to prior knowledge; and 3 points were awarded for report of a specific keyword or other mnemonic strategy. Summed strategy scores predicted recall test performance for both conditions, with Spearman correlations of .390 ($p < .03$) and .569 ($p < .001$) for mnemonic and traditional conditions, respectively. No students reported use of mnemonic strategies for information taught by traditional methods. This was true even for students in class 4, who had received traditional instruction preceded by 6 weeks of mnemonic instruction. In that class (see Figure 5), students average scores in mnemonic conditions exceeded significantly their performance under traditional instruction, according to a Wilcoxon Matched-Pairs Signed Ranks test (Siegel, 1956) ($z = 2.02$, $p < .05$). Similarly, averaged mnemonic strategy scores from that class exceeded strategy scores from the traditional instruction chapter, by the same margin ($z = 2.02$, $p < .05$).

Consumer Satisfaction Reports

Student satisfaction survey data. Students were asked by their teachers at the end of the 2-month unit to complete group-administered surveys of their attitudes and opinions of the materials. Twenty-four of the 27 students were available to complete this survey. Of these, 23 students reported enjoying the mnemonic pictures; and 23 agreed that they learned more from mnemonic pictures than from traditional materials. Twenty-one respondents agreed that they learned more than usual with mnemonic pictures, and 20 felt they had earned better grades with mnemonic instruction. Fourteen responded that they would like to use similar materials in other classes and mentioned a variety of other courses in which they felt mnemonic instruction would be appropriate (e.g., science, language arts, and health). Finally, when asked how they usually studied history content, students provided simple study strategies, such as "take notes," "answer questions in text," "ask myself questions," "think about the information," or a combination of these strategies.

Teacher satisfaction data. Teachers were asked to complete a BIRS evaluation of the appropriateness of the instructional strategy, for each student, for both traditional and mnemonic instruction. Mnemonic

FIGURE 5 Delayed recall scores by class, chapter, and condition



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condition instructional materials were rated significantly more appropriate for the instructional needs of individual LD students than were the traditional materials, according to a Wilcoxon Matched-Pairs Signed-Ranks test applied to summed BIRS item scores ($z = 3.52$, $p < .001$). In addition, a teacher satisfaction survey completed by the three participating teachers indicated that all teachers enjoyed using the experimental materials and found them easy and convenient. All teachers reported that their students were more motivated to learn, were more interested in their own school performance, and participated in class discussions more when mnemonic materials were used.

DISCUSSION

Results of this investigation suggest that classroom materials can be adapted to mnemonic instruction and implemented by classroom teachers over extended periods and that use of these materials can result in substantially higher performance for students with a history of learning problems, both immediately and for delayed intervals of, at least, 8 weeks. Furthermore, both students and teachers were positive in their assessment of the materials and the degree to which they were perceived as facilitating learning and recall of U.S. history content.

The research design employed allowed for an evaluation of the degree to which LD students would transfer spontaneously the use of mnemonic elaborations to new information presented nonmnemonically. It was found that after 2, or even 6, weeks of mnemonic instruction, students did not report transferring mnemonic strategies, nor did their performances on nonmnemonic chapters suggest that they had transferred these strategies. Student performance, in each case, dropped dramatically when nonmnemonic instruction was introduced. This outcome was not surprising, considering the complexity of the strategy and the documented problems of transfer or generalization found in special populations (Scruggs & Mastropieri, 1984). It is possible, nevertheless, that transfer of these strategies could be induced by providing students with intensive training (Mastropieri & Scruggs, 1987). Strategies that do not immediately promote transfer, however, may still be of great value in promoting learning of handicapped populations. Loper and Hallahan (1982), for example, reported "we are alarmed at what we perceive to be a tacit premise that if instruction results in generalizable results, then, and only then, was the instruction adequate" (p. 64). Although generalized use of complex mnemonic strategies may be desirable and is worthy of further research (e.g., McLoone et al., 1986), it should be remembered that mnemonic instruction has at least as much to do with how teachers should teach as it does with how learners should learn (Pressley, Scruggs, & Mastropieri, in press).

Pressley, Scruggs, and Mastropieri (in press) have recently described a logical progression of memory strategy research, from documentation of strategic deficits in specific populations, experimental evaluation of individual memory strategies applied in controlled laboratory conditions, to adaptation of classroom materials, and finally evaluation of those materials and procedures in actual classroom settings. The study described here is in keeping with one instance of such a logical progression. First, a body of empirical evidence has documented deficits in memory functioning of LD students, particularly as these deficits pertain to recall of verbal information (e.g., Swanson, 1987a). Second, the application of a variety of specific mnemonic systems has been evaluated in tightly controlled, laboratory-like settings with LD students (e.g., Mastropieri, 1988; Scruggs, Mastropieri, & Levin, 1987). Third, information gained from these experimental investigations led to the mnemonic adaptation of existing curricular materials (Scruggs & Mastropieri, in press-b). Finally, in this investigation, mnemonically adapted materials were successfully applied in several different classrooms over an extended period. In all applications, LD students benefitted from the provision of mnemonic strategies. In the present instance, students who were previously characterized by negative attitudes toward school and classroom learning reported enjoying the use of mnemonic materials.

Although mnemonic strategies such as those employed in this investigation have been shown to benefit a variety of learner types (Scruggs & Mastropieri, 1985, 1988), it may be that these strategies are particularly appropriate for handicapped learners. First, students characterized as LD often exhibit deficits in the semantic knowledge base necessary for the easy acquisition of related new information. Mnemonic strategies appear to be particularly helpful with learners whose knowledge base is impoverished (Pressley, Johnson, & Symons, 1987). Second, these strategies provide systematic retrieval routes for LD students, who typically exhibit deficits in the spontaneous use of general learning strategies, such as categorization and elaboration (Ceci, 1986). Third, LD populations have been seen to be less motivated to learn and achieve than more average populations (e.g., Oka & Paris, 1987). Results of the present and ongoing investigations (e.g., Scruggs & Mastropieri, in press-a) suggest that teachers and students alike report that mnemonic materials can have a positive effect on motivation.

Finally, mnemonic instructional strategies may serve an important function for the content-area learning of students who have deficits in basic skills. History content is typically conveyed through classroom lectures, with important points perhaps noted on the blackboard. Students are typically required to attend to lectures, take notes, and study both notes and text information outside of class to promote long-term retention of the information. Learning disabled students, however, in addition to memory deficits, may be unable to take notes effectively because of poor writing skills and may be unable to study the text because of reading deficiencies. In this study, the mean reading grade equivalent of 3.0 was not sufficient to read and to comprehend most U.S. history textbooks. What is required for these populations, then, is an alternative means for promoting content-area learning. By means of mnemonic instruction, LD students are provided with powerful learning strategies that can insure that the most important points in a given content area will be learned and remembered, even if they lack the basic skills necessary for independent studying.

As argued previously (e.g., Mastropieri, Scruggs, & Levin, 1987), mnemonic instruction should not be regarded as an educational panacea. Additional instructional strategies are needed to meet all relevant instructional objectives of LD students (Mastropieri & Scruggs, 1987). It appears, however, that mnemonic instruction can play an important role in special education. As Lebrato and Ellis (1974) argued in a paper evaluating the mnemonic pegword method with retarded learners, "mnemonics may be a powerful tool in increasing learning and retention of educational materials, many of which must be learned in a rote fashion. In view of the poverty of truly *special* training and educational methods . . . this method bears careful and intensive study" (pp. 712-713).

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The research described in this report was supported in part by a grant from the U.S. Department of Education, Special Education Programs (G008730144-88). The authors would like to thank the teachers, staff, and students at School 72 in Indianapolis, particularly Dr. Robinson, principal, and Ann Marie Domek, Judy Little, and Cecilia Mimms, teachers. We would also like to thank Dr. C. Richard Norris, of the Indianapolis Public School District, and Dr. Jim Hamilton, of the U.S. Department of Education, for their assistance and feedback.

Appendix F

Mastropieri, M.A., & Scruggs, T.E. (1989a). Constructing more meaningful relationships: Mnemonic instruction for special populations. Educational Psychology Review, 1, 83-111.

Educational Psychology Review, Vol. 1, No. 2, 1989

Constructing More Meaningful Relationships: Mnemonic Instruction for Special Populations

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This article describes a model for reconstructing associative learning tasks along the dimensions of meaningfulness and concreteness, and for providing pictorial elaborations between stimulus and response information to promote learning in a variety of content domains. The research reviewed is of direct relevance to students with histories of learning failure in schools; we argue that such elaborative strategies are suitable especially for these handicapped learners. Initial investigations of mnemonic techniques involving the use of keywords and pegwords are described. Next, the broader approach of "reconstructive elaborations," incorporating such strategies as the keyword method, is described. Several recent field investigations are presented, in which this approach was implemented in classrooms over extensive time periods. Finally, we discuss future applications, with particular reference to the transfer issue.

KEY WORDS: mnemonics; learning disabilities; special students.

INTRODUCTION

Nowhere is the search for efficient learning techniques more important than in the area of applications to student populations characterized by learning failure. Recently, volumes of published literature have gone into great depths to explore causes and characteristics of these learning failures (e.g., Ceci, 1986, 1987; Swanson, 1987). However, much less has been accomplished with respect to developing appropriate applications of instructional or learning techniques to contribute to the solutions of these problems.

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Kail and Leonard (1986) argued that research "should be based as much on the quest for instructionally relevant information as on the search for differences between learning-disabled children and their peers on tasks that are state-of-the-art but instructionally vacuous" (p. 200). In fact, such research recently has been conducted, and the resulting effects have been among the most consistently positive in all of special-education research. This paper discusses the evolution of specific mnemonic techniques from laboratory-based investigations with experimenter-developed tasks, into large-scale, classroom-based investigations using existing curricular materials and teacher implementations. First, we discuss initial mnemonic explorations using specific mnemonic techniques, such as the keyword and pegword methods, and the role of these studies in developing the model of reconstructive elaborations and its basis in the dimensions of meaningfulness, concreteness, and verbal elaboration. After describing the approach, we describe its application in several recently conducted, large-scale investigations with mildly handicapped learners. Finally, we describe our perspectives on the future of mnemonic classroom instruction, with specific relevance to the issue of transfer.

MNEMONIC STRATEGIES

Atkinson (1975) first employed the keyword method in teaching Russian vocabulary to undergraduate students. Pressley (1977) later employed the method with children, and Pressley *et al.* (1982) described the early history of the keyword method with average or above-average learners. Shortly afterward, Mastropieri *et al.* began to study applications of mnemonic techniques with handicapped learners. Although the research literature reveals previous investigations of elaborative or mnemonic techniques applied to handicapped learners (e.g., Rohwer, 1968; Lebrato and Ellis, 1974), it is only within the last few years that a systematic body of research literature has emerged that focused on possibilities of these techniques with curriculum-relevant tasks. Pressley *et al.* (1989) have described a model for the systematic exploration of specific cognitive strategy instruction, from initial evaluation of the need for and effectiveness of specific strategies in laboratory-like situations to further explorations of more complex applications and broader-based implementations in classrooms, using teachers as implementors and existing curricula as "experimental" tasks. From the perspective of the model, it is important to begin by documenting relative deficiencies in the learning processes of the targeted population. Such documented deficiencies not only provide justification for the research program, they also imply the type of cognitive strategy likely to be effective with this population. Initially, it is important to determine the effectiveness of a specific cognitive strategy with a specific population sample under ideal conditions. If such a procedure is ineffective, alternative procedures must be developed and evaluated. If the procedure is demonstrably effective, however, further explorations may be necessary to resolve specific issues regarding the use of the strategy, such as the degree of general applicability or any possible negative "trade-off" effects. Given that the strategies are generally effective in optimal, one-to-one situations, it is important to extend the model, in carefully controlled steps, into evaluations in real classroom situations.

We have engaged in just such a program of research with mildly handicapped students (generally, students characterized as "learning disabled") over the past several years (see Mastropieri *et al.*, 1987b; and Scruggs *et al.*, 1987a, for previous reviews). In this article, we describe this research with respect to the sequence suggested by Pressley *et al.* (1989). First, we describe some of the research supporting relevant strategy deficits in our targeted populations and provide implications for mnemonic strategy research. Next, we describe our initial investigations which evaluated the potential of specific mnemonic strategies. Finally, we describe ongoing research involving large-scale adaptations of these strategies in classroom settings.

Memory and Learning Disabilities

Recently, researchers have targeted deficits in memory as an important characteristic in many students characterized as learning disabled (LD) (e..g, Torgesen and Houck, 1980; Torgesen and Goldman, 1977). Several other researchers have maintained that the observed memory deficits may be language-based (Swanson, 1987; Vellutino and Scanlon, 1982). Baker *et al.* (1987) have argued that LD students exhibit deficits in the *structure* (how information is stored and organized) as well as the *process* (operations carried on semantically stored information) of semantic memory. Baker *et al.* maintained that structural deficits result in lessened ability to name, describe, and remember verbal information; while process deficits may contribute to continued structural deficits. Similarly, Kail and Leonard (1986) have attributed "word finding" problems of a subset of disabled learners to inadequate representations of words in memory, as well as basic deficiencies in language-based information retrieval. Ceci (1985) provided evidence that LD students are relatively deficient at purposive, rather than automatic, semantic processing, and concluded that his findings

> . . . suggest that instead of advocating intervention plans that are directed at remediating alleged cerebral insult or dysfunction, a more profitable approach to children with semantic processing difficulties. . . is to train purposive information-processing strategies like elaborative encoding, chunking, anticipation, type 2 rehearsal, and so on (p. 219).

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One such elaborative learning strategy that appears to be appropriate is the mnemonic keyword method (Atkinson, 1975). The keyword reconstructs unfamiliar verbal stimuli into acoustically similar representations, and elaborates the reconstructed stimuli with response information. For example, to learn that the scientific root *ornith-* means "bird," an acoustically similar keyword for ornith (oar) can be shown interacting with the response; in this case, a picture of a *bird* carrying an *oar*. Learners are told, for example, when asked for the meaning of *ornith-*, to think of the keyword, think of the picture with the keyword in it, remember what else was happening in the picture, and provide the correct response: bird. The keyword method was thought to be of potential benefit to learning-disabled or other mildly handicapped learners because it provides specific procedures for encoding and retrieving verbal information, and because previous research has documented the efficacy of the strategy with learners of average or above-average abilities (Pressley *et al.*, 1982, 1987).

Nevertheless, the success of keyword strategy instruction with LD students was far from a foregone conclusion for several reasons. It was possible that LD or otherwise mildly handicapped learners could not meet the information processing demands of keyword instruction, especially when the method was to be applied to more complex tasks. Would LD students be able to discriminate semantically relevant (response) from semantically irrelevant (retrieval) information within specific mnemonic images; would they be able to incorporate different types of mnemonic strategies over time; would information learned mnemonically be semantically meaningful to LD students; could LD students use these strategies or components of these strategies independently; and would such strategies facilitate long-term recall? Studies that investigated these issues are now described.

INITIAL MNEMONIC EXPLORATIONS

Vocabulary Learning

Once specific memory deficits have been documented, it is important to determine whether specific memory strategies can be effectively employed under optimal circumstances (Pressley *et al.*, 1989). Initial vocabulary acquisition using experimenter-developed word lists provides a good test of such strategies. In two experiments, Mastropieri *et al.* (1985c) taught learning-disabled middle-school students a list of 14 low-frequency English vocabulary words, using either a keyword condition or an experimenter-led drill and practice ("direct instruction") condition, using rehearsal as the dominant learning strategy. The vocabulary list (e.g., carline = witch; dogbane = plant; bugsha = money) and one-to-one teaching provided a most simple and efficient example of mnemonic instruction. All the vocabulary words lent themselves to "obvious" keyword reconstructions (e.g., carline = car, dogbane = dog, bugsha = bug) and easily pictured interactions between keywords and highly concrete and familiar responses (e.g., a *witch* driving a *car*, a *dog* eating a *plant*, a *bug* sitting on a stack of *money*). The vocabulary-learning task, in this instance, essentially involved learning new labels for previously learned concepts or entities. The alternative instructional condition was developed based upon notions of "optimal" instructional procedures for special education (Becker *et al.*, 1982). Had optimal traditional instruction proved to be a superior method of promoting learning under these circumstances, the mnemonic strategy could be considered to be of questionable utility for special education, and further research would be needed to investigate whether keyword instruction could be shown to be of any use for mildly handicapped students. However, in this investigation, LD students instructed mnemonically greatly outperformed students instructed by more traditional drill-and-practice methods. In addition, in a second experiment, LD students were asked to generate their own interactive images in the keyword condition, and still far outperformed rehearsal-based control students. In a similar study, mnemonic instruction was found to be superior to drill-and-practice methods in facilitating the vocabulary-learning of mildly mentally retarded students (Scruggs *et al.*, 1985). Results of this investigation augmented the support for the initial promise of such acoustically reconstructed stimuli with populations defined as having low IQs. Berry (1986), in two experiments, also reported that keyword vocabulary instruction had been highly successful with a similar age group of LD students.

In another vocabulary-learning investigation, McLoone *et al.* (1986) compared mnemonic instruction and direct instruction-rehearsal in learning English and Italian vocabulary. After the first learning task, in which mnemonically instructed students again far outperformed control students, students in the keyword condition were asked to generate their own keyword and interactive images. They again outperformed students instructed to rehearse the vocabulary words. In part of a larger study (described in more detail below), Veit *et al.* (1986) taught, among other things, Greek root words (e.g., ptero- = winged; saur = lizard) to LD adolescents using the keyword method or experimenter-led drill and practice. Mnemonically instructed students showed superior recall performance and also were more able to apply the information when entire prehistoric reptile names were provided (e.g., *ptero/saur* = winged lizard).

Most recently, Mastropieri *et al.*, (1989) evaluated the effectiveness of mnemonic keyword instruction on recall and comprehension of both abstract

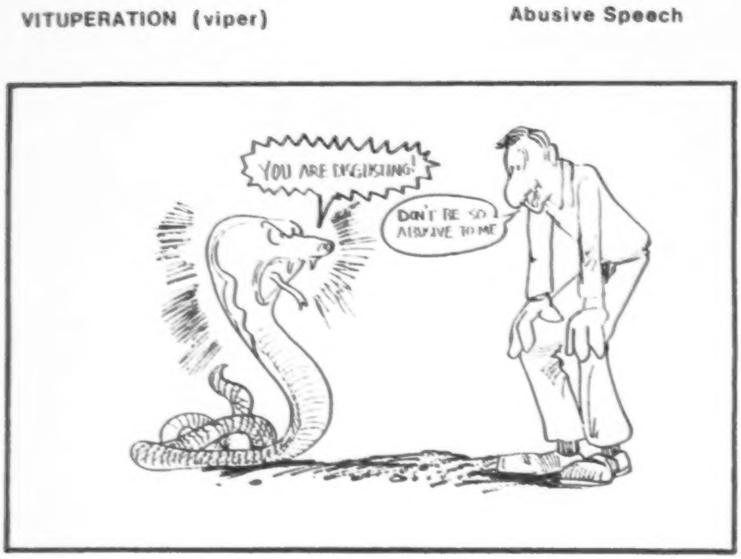

Fig. 1. Mnemonic illustration for the meaning of "vituperation." In this example, a single vocabulary word is paired with its meaning.

and concrete vocabulary words with LD junior high school students. In this instance, the vocabulary words did not represent new labels to already familiar concepts, and they were not notable for keyword "obviousness" (e.g., vituperation, saprophytic, nepenthe; see Fig. 1). In fact, they were taken from a list used by Johnson, Adams, and Bruning (1985) to teach vocabulary words to college students, and in which it was reported that the keyword method was unsuccessful in facilitating recall of abstract words. Mastropieri *et al.* (1989), however, reported that mnemonically instructed LD students greatly outperformed rehearsal-condition students on learning the abstract and concrete words, and on production recall as well as on a comprehension task.

The results of these initial vocabulary-learning studies, taken together, provided positive implications for use of the keyword method with special populations. They also provided the foundation for the investigation of more complex mnemonic systems, described in the next section.

Mutliple Mnemonic Systems

Based in part upon the success of the relatively simple vocabulary-learning studies, a series of studies explored the utility of mnemonic instruc-

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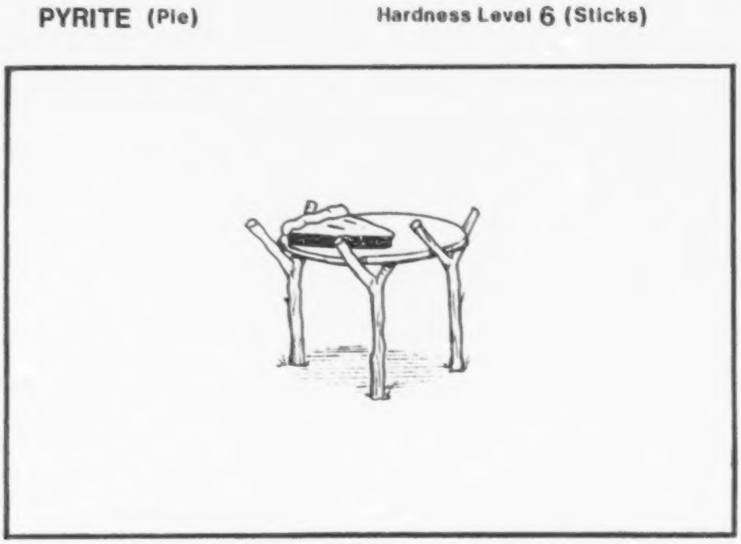

Fig. 2. Mnemonic illustration depicting the hardness level (6) of the mineral *pyrite*. In this example, the mineral name is depicted by the keyword "pie," and the hardness level by the pegword "sticks."

tion involving pegwords (for numbered or ordered information) and the teaching of several simultaneous responses to a given stimulus. Mastropieri *et al.* (1985b) taught LD adolescents the hardness levels of North American minerals, according to Moh's scale, using a mnemonic keyword-pegword (one is bun, two is shoe, etc.) technique; that is, to teach that *pyrite* is number six on the hardness scale, students were shown a picture of the keyword (pie) interacting with the pegword (e.g., for six = *sticks*, a picture of a pie on sticks; see Fig. 2). This procedure added an additional retrieval step, and included an additional acoustic reconstruction; nevertheless, mnemonically instructed students outscored rehearsal-condition and free-study-condition students by a wide margin. Additionally, data provided by Mastropieri (1983) indicated that mnemonically instructed students maintained their performance advantage over a 24-hour delayed recall interval. In a replication, Mastropieri *et al.* (1986) reported that the keyword-pegword method was effective when taught to LD students in their regular instructional groupings (Exp. 1) and when taught to mildly mentally retarded students (Exp. 2). In a study involving average learners, Scruggs *et al.* (1986b) found that redundancy in response (pegword) information was not confusing to the learners. Further, the 56 mineral names used in that investigation were not chosen for keyword "obviousness," but rather were drawn at random from a field guide to North American minerals.

Since the keyword-pegword strategy was successful, we initiated several investigations to evaluate the effectiveness of mnemonic pictures that conveyed multiple attributes of minerals and employed different mnemonic systems. Scruggs *et al.* (1985) taught learning-disabled adolescents common colors and uses of specific minerals, in addition to hardness levels, by employing more complex mnemonic pictures incorporating different mnemonic systems integrated within one illustration per mineral.

For example, to teach that *pyrite* was not only number six on Moh's hardness scale, but also that it was *yellow* and used in the manufacture of *explosives*, an integrated mnemonic picture could be shown of a *yellow pie* resting on some *explosives* and held up by *sticks* (Fig. 3). Learners would then be told that, when asked for information about pyrite, to think back to the picture to retrieve all the information. The sticks represented a pegword for hardness level six, as in the Mastropieri *et al.* (1985b) investigation. However, the color (yellow) and use (explosives) would be represented

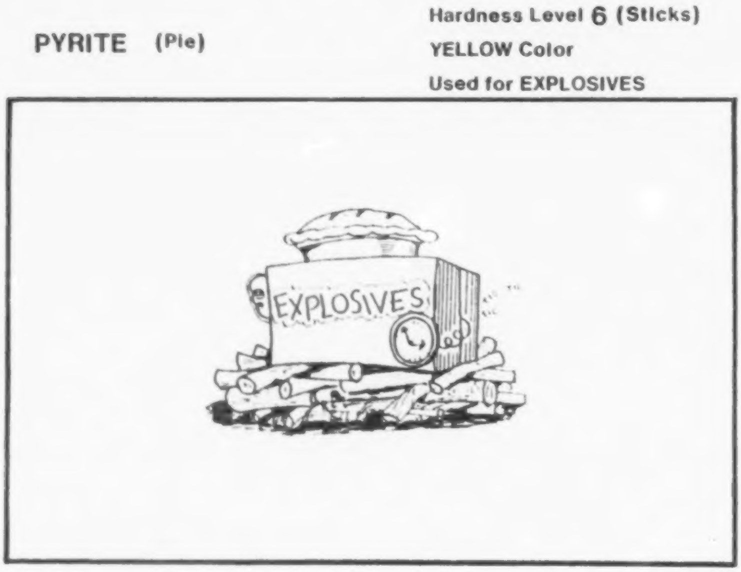

Fig. 3. Mnemonic illustration depicting three attributes of the mineral *pyrite*. The keyword and pegword have been retained from Fig. 2, but the attribute "explosives" (use) has been represented literally. Additionally, in the original picture, the pie was colored yellow, representing mineral color.

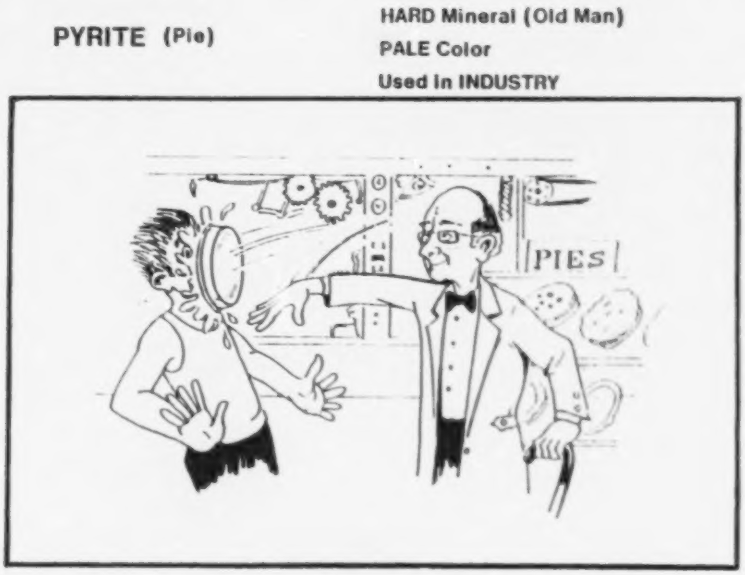

Fig. 4. Mnemonic illustration depicting three dichotomized attributes of the mineral *pyrite*. The *not-blackened-in* pie symbolizes "light" (vs. dark) color; the *old man* symbolizes "hard" (vs. soft) mineral; and the *factory* scene symbolizes "industrial" (vs. home) use.

literally. Learners would be expected to understand, then, that *sticks* represented an acoustic numerical reconstruction, but *yellow* and *explosives* were intended to be interpreted literally. Furthermore, it was not known whether colors in mnemonic pictures would be as easy to retrieve as were literal pictures of, for example, explosives. Nevertheless, in this investigation, students instructed using mnemonic pictures similar to that in Fig. 3 significantly outperformed students under free-study or direct drill-and-practice conditions on all three attributes.

A subsequent investigation was designed to determine whether other types of pictures would be memorable, as well as pegwords and mimetic representations of color and use. In this study, Mastropieri *et al.* (1985d) developed mnemonic pictures to represent symbolized dichotomies of response information. For example, instead of teaching that pyrite was number six on the hardness scale, yellow in color, and used in the manufacture of acid, we attempted to teach that pyrite was a relatively ***hard*** mineral, ***light*** in color, and involved in ***industrial*** use. We used symbolized responses in this case, to represent these dichotomies: hardness was symbolized as an *old man* (hard mineral) or a *baby* (soft mineral); color was represented by the

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keyworkd *blackened in* (dark) or *not blackened in* (light); finally, use was symbolized by portrayal of the keyword information in a *factory* scene (industrial use) or a *home* scene (home use). In the pyrite example, an old man could be shown throwing a (not blackened in) pie in a factory setting (Fig. 4). This investigation was intended to determine (a) whether LD students could benefit from the provision of symbolic reconstructions of response information, and (b) whether the repeated presentation of several attribute dichotomies (e.g., several "old man" representations) would interfere with learning. Mastropieri *et al.* (1985d) reported that, again, mnemonically instructed students greatly outperformed students in free-study and experimenter-led rehearsal conditions.

In another replication and extension, Scruggs *et al.* (1986c) found that the mnemonic presentation of both specific mineral attributes (Exp. 1) and dichotomized mineral attributes (Exp. 2) resulted in higher levels of recall when compared with "visual-spatial display" presentations (Engelmann and Carnine, 1982) of the same content. Results of these "multiple-attribute" studies suggested that special populations can benefit from the provision of more complex mnemonic strategies, encompassing larger amounts of information, and provided further implications for content adaptation.

Extended Mnemonic Instruction

Two limitations of the studies reviewed to this point are that they all involved single presentations of a list of related associative information, and that, with one exception (Mastropieri *et al.*, 1986), all were implemented with individual students. Such research is necessary in initially validating specific cognitive strategies with specific population samples (Pressley *et al.*, 1989). However, it also was important to determine the extent to which such instruction could be effective when several different mnemonic systems were implemented over several days of instruction to students in more ecologically valid, small instructional groups. To evaluate this issue, Veit *et al.* (1986) developed three lessons pertaining to the study of prehistoric reptiles. The lessons were developed to be nonoverlapping in content, so that presentation order could be counterbalanced across instructional groups.

Each lesson included different mnemonic procedures. One lesson involved teaching vocabulary root words, and tested whether students could later translate combinations of those word parts to form the names of specific prehistoric reptiles (e.g., ptero/saur, ornitho/pod).

A second lesson taught three attributes each of eight prehistoric reptiles, as in the mineral investigations, and additionally tested whether specific colors could be used to symbolize an attribute dichotomy. In this case, pictured keywords colored *red* symbolized *carnivores,* while pictured keywords colored *green* symbolized *herbivores*. Additionally, a morning, midday, or night setting symbolized the *early* (Triassic), *middle* (Jurassic), or *late* (Cretaceous) period of the Mesozoic Era in which each particular prehistoric reptile was found. Finally, a mimetic, representative picture was given of an attribute specific to each particular prehistoric reptile, such as "brain the size of a walnut," or "walked on four legs."

In a third lesson, possible explanations for the extinction of dinosaurs and other prehistoric reptiles were presented, in order of plausibility, by means of interacting pegwords. For example, reason number five, that dinosaurs were killed off by diseases was represented by a picture of a *sick* dinosaur in a hospital bed looking at a bee *hive*. These lessons were taught by experimenters to LD middle-school students in their regular instructional groupings, over a three-day period. Twenty-four such groups were randomly assigned to either the mnemonic conditions described above, or an experimenter-led drill-and-practice condition, which included fast-paced presentation rates, direct questioning, choral responding on cue, immediate feedback, and cumulative review of each lesson's information. Mnemonically instructed students outperformed comparison-condition students on all individual lessons, as well as on a fourth-day cumulative recall test. Additionally, analysis of test scores across lessons over time revealed no relative decrease in performance over the three days of insruction. (Neither, however, was there any apparent increase in performance over time.) Finally, no evidence of confusion, as manifested by within-lesson or across-lesson intrusions, was evidenced under mnemonic instruction. Veit *et al.* (1986) concluded that mnemonic instruction was a potentially powerful technique for extended, small group instruction of special education students.

Prose Adaptations

Research described to this point has involved explicit instruction by trained experimenters, requiring little independent effort on the part of the learner. Two investigations that followed evaluated the efficacy of mnemonic pictures when embedded within prose passages, in which learning-disabled students were required to read and utilize mnemonic pictures independently. Scruggs *et al.* (1987b) embedded pictorial mnemonic representations of dichotomized mineral attributes (Exp. 1) as well as specific mineral attributes (Exp. 2) within prose written on the approximate reading level of high school LD students. In both experiments, students who used mnemonic materials scored substantially higher than students who read the same passages that incorporated only representative pictures and no explicit mnemonic retrieval instruction. Additionally, in Experiment 2, students who had been presented with mnemonic representations of specific mineral attributes were more likely to infer mineral attribute dichotomies, and also were more likely to recall the information one week later.

In a follow-up investigation, Mastropieri *et al.* (1987a) designed prose materials that discussed the reasons for dinosaur extinction. The mnemonic materials embedded the pegword system as in the Veit *et al.* (1986) study. A second set embedded simple representational illustrations, while the final set included no illustrations and served in the no-picture control condition. Junior high LD students were randomly assigned to one of the three experimental conditions, and students were asked to read through the experimental booklets independently. All students were tested following independent reading. Results indicated that mnemonically instructed students outperformed both control groups on measures involving recall of the order of plausibility for extinction.

The results from both prose studies indicated that LD readers profited from mnemonic illustrations. These results contradict some previous findings (e.g., Harber, 1980), in which illustrations were thought to have interfered with LD students' ability to comprehend textual material.

CURRICULAR ADAPTATIONS

The mnemonic investigations described above, taken together, suggest that mnemonic strategy instruction could be a powerful means for improving learning in special-education settings. Nevertheless, some major issues remained to be addressed by this research. The actual potential for adapting existing curricular materials to mnemonic instruction was unclear. A study by Condus *et al.* (1986) had documented the effectiveness of classroom vocabulary instruction with LD students over a five-week period, including a 10-week retention interval, but the implications for content area instruction were uncertain. Further, the potential for LD students to use these strategies independently was unknown.

Reconstructive Elaborations

The first area we chose for curricular adaptation was United States history. Within this area, we selected the chapter on World War I for adaptation. We soon found that a substantial amount of the content did not immediately lend itself to keyword-type reconstructions. The reason for this lack of adaptability was that keyword-type reconstructions are most appropriate when the information to be learned is not familiar (or meaningful) to the learner. According to Mastropieri *et al.* (1985a), "the recoding component of the keyword method serves to transform unfamiliar, nonmeaningful stimuli into more meaningful entities" (p. 40).

Our examination of U.S. history content revealed that much information to be learned has components already meaningful to the learner, although such information may or may not be concrete and, therefore, easily pictured. Therefore, we evaluated all content in the World War I chapter with respect to the presumed meaningfulness of the content to the target learner population. If meaningful, we further examined the concreteness of the information, and therefore the degree to which that information could be easily pictured. We then developed a model of "reconstructive elaborations" in which all stimuli and response items were reconstructed along the dimensions of meaningfulness and concreteness. The stimuli were then elaborated, in an interactive picture, to facilitate both response learning and associative learning (Underwood and Schulz, 1960). We found that virtually all information presented in the history text could be classified as (a) meaningful/concrete, (b) meaningful/abstract, or (c) nonmeaningful and therefore (to the learner) neither concrete nor abstract (Mastropieri and Scruggs, 1989b). Adaptations made on this content are described in the following section.

Acoustic Reconstructions

Some information is nonmeaningful to learners when first presented. This information includes unfamiliar names of people, places, and events, and unfamiliar vocabulary words. In such cases, any possible reconstruction can be based only upon the *sound* of the verbal material; therefore, nonmeaningful information can be reconstructed *acoustically* by means of the keyword method. By means of the keyword method, nonmeaningful information is reconstructed into concrete, meaningful representations closely tied to the original stimulus item by acoustic similarity. By elaboration with the response, then, the associations are made firm between response, keyword, and stimulus. Since acoustic encoding developmentally precedes semantic encoding (e.g., Torgesen and Kail, 1980), a method relying upon acoustic similarities is likely to be effective with learning-disabled students who exhibit delays in language development. In fact, recent research has supported this hypothesis (Mastropieri *et al.* 1989).

In the instance of the World I chapter, a keyword strategy was used to facilitate recall of the Zimmerman incident, in which a German foreign minister sent a coded note to Mexico urging that country to join Germany in the fight against the United States. Since "Zimmerman" was not thought to be familiar to learners, an acoustic reconstruction was made with the keyword "swimmer" and an interactive picture was shown in which a swimmer was carrying a note to Mexico (Fig. 5).

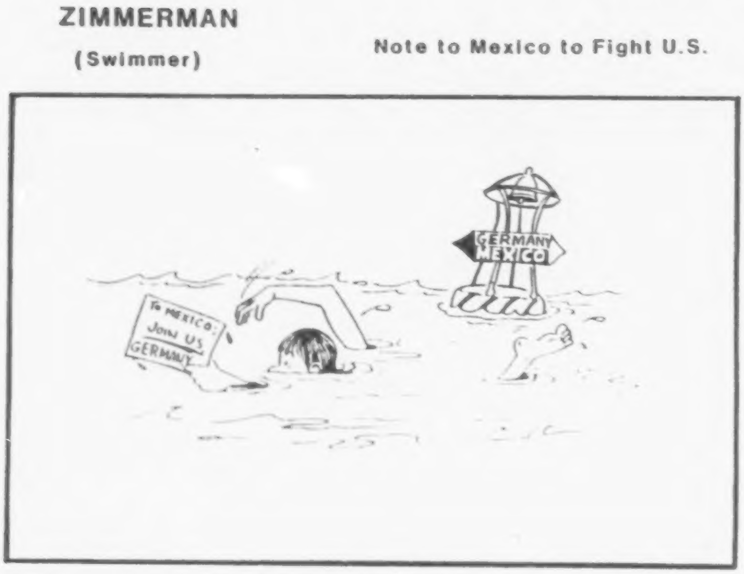
ZIMMERMAN
(Swimmer)
Note to Mexico to Fight U.S.
To MEXICO: JOIN US GERMANY
GERMANY
MEXICO

Fig. 5. Acoustic (keyword) reconstruction of the *Zimmerman* incident, in which a "swimmer," representing the keyword for Zimmerman, is carrying a note from Germany to Mexico.

Symbolic Reconstructions

Some information already is meaningful and familiar to the learner, but is abstract, and therefore can not be elaborated easily in an interactive picture with the response information. Such information can be reconstructed *symbolically*, and then represented in an interactive picture, as in the acoustic reconstructions described above. According to Paivio, "the word *religion* may evoke an image of a church as an associative reaction, and a picture of a church might arouse *religion* as an associate, but both are likely to be mediated by the implicit verbal associate *church*. This would be an instance of concretization of an abstract referent . . ." (1971, p. 60). Other examples of information that could be symbolically reconstructed include "liberty," "U.S. Policy," and "Republicans."

As previously noted, such symbolic reconstructions can have a powerful effect on learning and memory, as in the symbolic reconstructions of soft vs. hard minerals, carnivorous vs. herbivorous dinosaurs, and early, middle, and late periods of the Mesozoic Era. In these instances, however, the symbolic reconstructions were always used in conjunction with keywords. In the present model, symbolic reconstructions need not necessari-

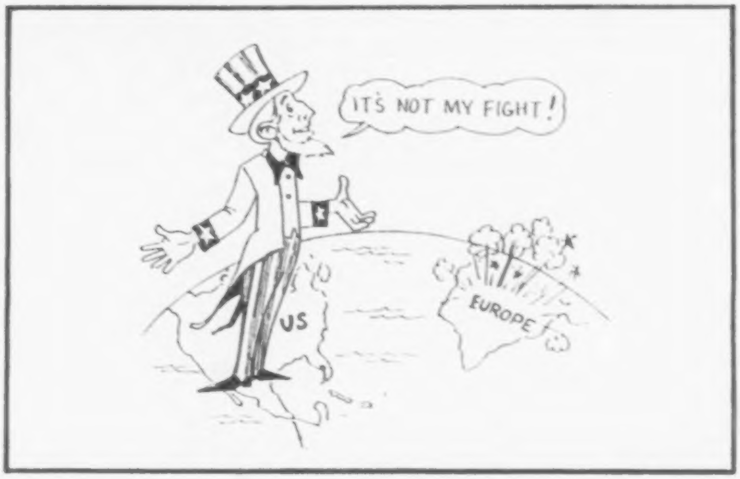
FIRST U.S. POLICY
(Uncle Sam)
Not to Take Either Side

Fig. 6. Symbolic reconstruction of American isolationist policy prior to World War I, in which Uncle Sam (symbol for U.S. policy) is shown not becoming involved with symbolized hostilities in Europe.

ly interact with keywords. For instance, the U.S. policy of neutrality prior to World War I was shown by the symbolic reconstruction of *Uncle Sam* looking across the globe to Europe, in which symbolized hostilities are depicted, and saying, "It's not my fight," as depicted in Fig. 6.

Mimetic Reconstructions

Some information already is concrete and familiar to the learner. In such cases, what needs to be learned are the associations, the knowledge that two familiar and concrete items "go together." This issue was explored many years ago (e.g., Jensen and Rohwer, 1963) with experimental associates such as "comb-glass" or "cow-ball." Simple verbal elaborations (e.g., "the comb is in the glass") were employed to facilitate the learning of mentally retarded individuals. However, perhaps due to the lack of educational relevance of the experimental materials, such practices did not appear systematically in special-education classrooms. In the present instance, it was necessary to teach that life in the World War I trenches was unhealthy (see Fig. 1), or that German submarines were obligated to sink, rather than seize, enemy shipping,

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TRENCHES -Unhealthy, many soldiers died

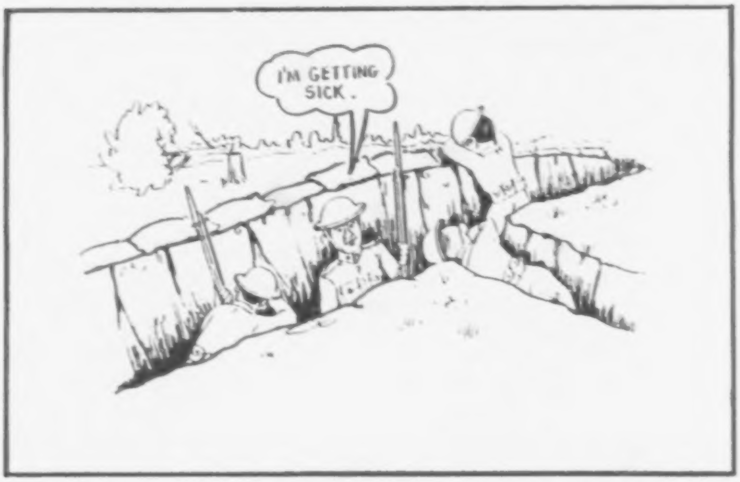
I'M GETTING SICK.

Fig. 7. Mimetic reconstruction of unhealthy conditions of World War I trenches, in which the stimulus and response information (trenches and sick soldiers) are pictured together.

because, once exposed, submarines could be destroyed by the deck guns of enemy ships. In these cases, mimetic pictures depicted the interaction of sick soldiers in trenches, or a German submarine rising to the surface and being shot by the enemy ship.

List Learning

It also became apparent that some stimulus information required a list of responses, rather than a single response. Although we originally sought to evaluate the effectiveness of the three types of reconstructions described above, it became apparent that we would have a difficult time demonstrating the ecological validity of the materials if they did not contain an accounting of the major countries involved in World War I and the alliance systems they represented. In order to teach this information, we created a keyword for each alliance system and pictured it interacting with an acronym for the first letters of the countries in each alliance system. For instance, to teach that the principal countries associated with the Central Powers were Turkey, Austria-Hungary, and Germany, we first created "Central Park" as a keyword for Central Powers, and showed a picture of children playing "TAG"

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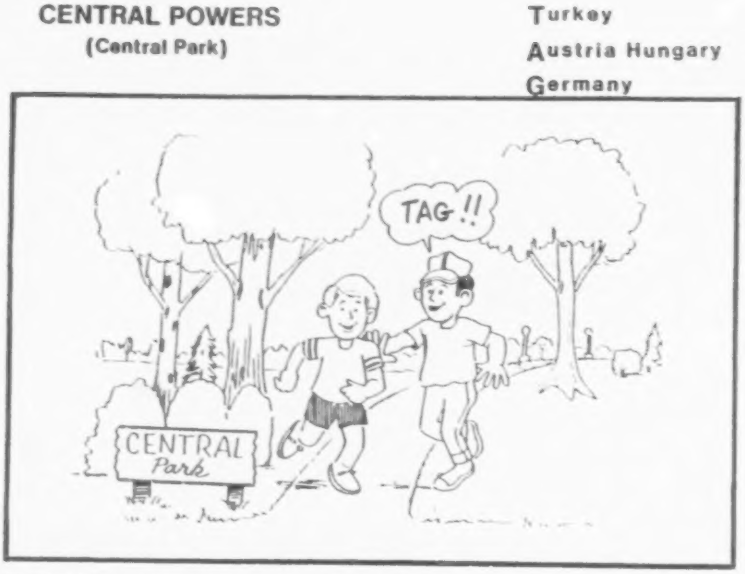

Fig. 8. Mnemonic first-letter strategy for retrieving the names of nations involved in the Central Powers. In this instance, an acoustically reconstructed keyword for Central Powers (Central Park) is shown as the setting for a game of "tag." The letters in the word "tag" represent Turkey, Austria-Hungary, and Germany, respectively.

in Central Park, as represented in Fig. 8. The letters of the acronym "tag," then, stand for three countries associated with the Central Powers. For Allied Powers, a "FIRE" was depicted in an "Allied Van" (keyword for Allied Powers), in which the letters in "fire" stood for the countries France, Italy, Russia, and England.

Validation

In order to validate this approach, Scruggs and Mastropieri (1989b) developed a text on World War I which incorporated 8 mimetic, 8 symbolic, and 8 acoustic reconstructive elaborations of the type described above, and the two first letter strategies for the alliance systems. This information was then taught individually to 30 mildly handicapped adolescents from secondary schools, who had been assigned at random to a mnemonic or experimenter-led control condition in which the experimenter presented the information, questioned the learner, and provided descriptive pictures of the type typically found in history books. Scruggs and Mastropieri (1989b) report-

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ed that mnemonically instructed students greatly outperformed control condition students on immediate as well as delayed recall, and that obtained effect sizes, as predicted, were highest for nonmeaningful information, next highest for meaningful/abstract, and lowest for meaningful/concrete information, although effects were statistically significant for all reconstructions, including the serial list (first letter) information.

Research Implementations

Several investigations have evaluated actual classroom applications of the reconstructive-elaborations model. In an initial investigation, Scruggs and Mastropieri (1989a) evaluated a teacher implementation of two mnemonically adapted chapters (World War I and the Great Depression) and two traditionally instructed chapters (The Roaring Twenties and World War II) from a commonly used U.S. history textbook (Rawls and Weeks, 1985). Three self-contained LD classrooms were instructed by the regularly assigned special-education teacher over a period of eight weeks. Chapter test scores were significantly higher when students were instructed mnemonically, and assigned grades, which reflected a more qualitative evaluation of student performance on tests, quizzes, worksheets, and class participation, rose from a nonmnemonic average of "D+" to an average of "B" when mnemonic materials were employed. Also, the teacher rated the materials as significantly more appropriate for the needs of her students, according to the Behavioral Intervention Rating Scale (BIRS) (Von Brock and Elliott, 1987). The within-subjects design allowed us to avoid such concerns as classroom by treatment confounding; however, in this study, a clear interpretation of the influence of relative chapter difficulty was inhibited. Nevertheless, it represented an initial classroom application and provided some encouraging results.

More recently, Mastropieri and Scruggs (1988) subjected the reconstructive-elaborations approach to a more rigorous evaluation by employing four learning disabilities classrooms and counterbalancing treatment orders. In this study, Classroom 1 received mnemonic instruction for chapters one and three. Classroom 2 received mnemonic instruction for chapters two and four. Classroom 3 received mnemonic instruction for chapters one, two, and three; and classroom 4 received mnemonic instruction for chapter four only. Since instruction was expected to continue over an eight-week period, and the school in which the classrooms were located was noted for a high level of absences and suspensions, this type of counterbalanced within-subjects design seemed optimal for testing the reconstructive elaborations approach. Mastropieri and Scruggs (1988) reported that students scored significantly higher on chapter tests, across chapters and across classrooms, when they had been instructed mnemonically. In addition, the differences favoring mnemonic instruction were maintained on an eight-week delayed recall unit test, which was implemented individually by experimenters who were "blind" to experimental condition. Finally, teachers rated the materials as significantly more appropriate to the learning needs of their students, as assessed by the BIRS. Further, all teachers reported their students appeared more interested and motivated to learn during mnemonic instruction. The students corroborated those reports by responding that they enjoyed instruction more under mnemonic conditions, and expressed the desire for mnemonic instruction in other subject areas, such as science and language arts.

In another implementation, Mastropieri and Scruggs (1989a) adapted Indiana history chapters (history of transportation and natural resources). The content was then taught, again in a counterbalanced within-subjects design across classrooms, by three special-education teachers in three elementary and middle schools, in six instructional groups, over several weeks of instruction. Again, mnemonic instruction resulted in substantial immediate and delayed recall gains over more traditional teacher-led procedures. Positive reports from both teachers and students also corroborated findings from the earlier investigations. All teachers enjoyed using the mnemonic materials, and perceived their students were learning more and enjoying learning.

Other smaller-scale investigations also have evaluated the reconstructive elaborations approach with mildly handicapped learners. Mastropieri *et al.* (1988a) reported on a teacher implementation of mnemonic instruction of science concepts, in which instructional condition (mnemonic and traditional) and content (food chains and invertebrate animals) were counterbalanced in a within-subjects design. In this case, mnemonic pictures were not provided by experimenters and artists, but were developed by the ingenuity of the (not artistically inclined) special-education teacher, who used stick figures and cutouts from magazines to develop mnemonic pictures. The results indicated that, when mnemonically instructed, students exhibited an immediate advantage in recall, which was maintained at above 90% correct responding over one-day, three-day, and one-week delay intervals. When instructed more traditionally, these same learners acquired less than 80% of the science concepts initially, and recalled only 40% one week later.

SUMMARY

Findings to Date

Table 1 presents a summary of all experimental investigations on mnemonic instruction with mildly handicapped learners of which we are aware, including brief descriptions of the tasks, procedures, control condi-

Table I. Mnemonic Studies

Reference	Sample	Task	Mnemonic condition	Comparison condition	% correct mnemonic vs.	Average effect size
Mastropieri *et al.* (1985)	Exp. 1 32 LD junior high school students	Vocabulary	Keyword	Direct instruction	79.5 vs. 31.2	2.52
	Exp. 2 37 LD junior high school students	Vocabulary	Keyword (no picture)	Direct instruction	69.3 vs. 46.7	1.08
Scruggs, *et al.* (1985)	20 EMR junior high school students	Vocabulary	Keyword	Direct instruction	71.5 vs. 48.0	1.18
McLoone *et al.* (1986)	60 LD junior high students	Vocabulary and training and transfer	Keyword	Directed rehearsal	79.0 vs. 35.0	1.95
Mastropieri, *et al.* (1989)	25 LD junior high school students	Vocabulary (abstract-concrete)	Keyword	Direct questioning (picture control)	66.7 vs. 22.1	3.25
Condus, *et al.*	64 LD elementary students	Vocabulary	Keyword	(a) Picture-context (b) Sentence-context	56.0 vs. 29.0	1.69
Berry (1986)	Exp. 1 80 fourth and fifth grade LD students	Vocabulary	Keyword	Picture	82.9 vs. 50.4	1.20
	Exp. 2 60 fourth grade LD students	Vocabulary	Keyword	Picture	77.0 vs. 44.0	1.70
Mastropieri *et al.* (1985)	90 LD ninth graders	Hardness of minerals	Combined keyword-pegword	(a) Free study (b) Direct questioning	79.0 vs. 27.9	3.42
Mastropieri *et al.* (1986)	Exp 1 56 LD high school students	Hardness of minerals	Combined keyword-pegword	Direct instruction	80.0 vs. 50.0	.85

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	Exp. 2 8 EMR junior high students	Hardness of materials	Combined keyword-pegword	Direct instruction	64.0 vs. 37.5	.68
Scruggs, *et al.* (1985)	56 LD junior high school students	Attributes of minerals: hardness, color, use	Keyword-pegword, color-mimetic, use-symbolic	(a) Free study (b) Direct instruction	69.3 vs. 27.1	1.33
Mastropieri *et al.* (1985)	36 LD junior high school students	Attributes of minerals: hardness, color, use	Keyword-pegword, (acoustic) color, symbolic use	(a) Free study (b) Direct instruction	94.8 vs. 70.1	3.14
Scruggs, *et al.* (1985)	Exp. 1 36 LD junior high school students	Attributes of minerals (continuous)	Keyword-pegword, color-mimetic, use-symbolic	(a) Free study (b) Visual-sptial display	58.3 vs. 27.3	1.31
	Exp. 2 36 fifth and sixth grade LD students	Attributes of minerals (dichotomous)	Keyword-pegword, color-symbolic, use-symbolic	(a) Free study (b) Visual-spatial display	86.8 vs. 62.7	1.67
Veit, *et al.* (1986)	64 LD middle school students	(a) Dinosaur word parts (b) Dinosaur attributes (c) Reasons for dinosaur extinction	(a) Keyword (b) Keyword representations, symbolic, mimetic representation (c) Pegword	(a) Direct questioning (b) Visual-spatial display and direct questioning (c) Direct questioning	53.7 vs. 29.7	1.05
Scruggs, *et al.* (1987)	Exp. 1 24 LD high school students	Prose passages (dichotomous attributes of minerals)	Keyword-pegword, color-symbolic, use-symbolic	Free study	93.0 vs. 55.0	2.85
	Exp. 2 24 LD high school students	Prose passages (continuous attributes of minerals)	Keyword-pegword, color-mimetic, use-symbolic	Free study	73.6 vs. 43.7	0.89

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Table I. Continued

Reference	Sample	Task	Mnemonic condition	Comparison condition	% correct mnemonic vs.	Average effect size
Mastropieri *et al.* (1987)	67 LD junior high school students	Prose passages (reasons for dinosaur extinction)	Pegword	(a) nonmnemonic picture (b) no picture	80.8 vs. 47.3	1.24
Scruggs and Mastropieri (1989b)	30 mildly handicapped secondary students (LD and MiMh)	1 chapter adapted from US history text	Acoustic-symbolic, mimetic, first letter	(a) Picture-control (b) Direct questioning	65.4 vs. 45.0	1.55
Scruggs and Mastropieri (1989a)	26 LD junior high school students	2 chapters adapted from US history text	Acoustic-symbolic, mimetic, first letter	Traditional	62.4 vs. 46.8	0.99
Mastropieri and Scruggs (1988)	27 LD junior high school students	4 chapters adapted from US history text	Acoustic-symbolic, mimetic, first letter	Traditional	75.6 vs. 44.0	1.38
Mastropieri and Scruggs (1989b)	17 mildly handicapped elementary students	2 chapters adapted from Indiana history text	Acoustic-symbolic, mimetic	Traditional	86.1 vs. 71.0	1.15
Mastropieri *et al.* (1988a)	8 BD elementary students	2 chapters adapted from science text	Acoustic	Traditional	94.5 vs. 58.8	0.91
Summary statistics	Total *N* = 983			Overall means	75.0 vs. 43.8	1.62

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tions, target populations, and obtained effect sizes. As is evident in Table I, the effect sizes are large and consistently positive. Since most of the research is our own, we can add with some confidence that "file drawer" problems (Rosenthal, 1979) are unlikely, as all formal investigations with handicapped learners undertaken by us are reported in this table.

The magnitude and consistency of the overall effect sizes ($M = 1.62$, SD = 0.79) are, we believe, the most positive of any synthesis of special-education research conducted to date. As comparison, Kavale and Forness (1985) reviewed quantitative syntheses of intervention research in special education in a variety of areas, and reported a range of average effect sizes from −0.12 to 0.58, for such interventions as reducing class size, special class placement, psycholinguistic training, perceptual motor training, stimulant and psychotropic drugs, and diet interventions. In addition to the overall low average effect size (0.24), Kavale and Forness (1985) reported that in each case the magnitude of the standard deviation exceeded the mean effect size. This suggests that, for all these interventions, there were instances of negative effects (i.e., that control-condition students outperformed experimental condition students). In contrast, mnemonic instruction has resulted in uniformly positive effects (range = 0.68 to 3.42), when compared with a variety of alternative treatments. It also is interesting to note that effect sizes for experimental, laboratory-type studies are very similar in magnitude to those found for the larger-scale, field-based evaluations. This suggests that, contrary to the opinion of some critics (e.g., Shepherd and Gelzheiser, 1987), laboratory-type experiments can be good predictors of the classroom potential of specific cognitive strategies (see also Pressley *et al.*, 1989, for additional commentary).

Limitations

Teacher Generation

At this point, we feel very optimistic that mnemonic instruction can result in tangible positive benefits to mildly handicapped students' learning. Several limitations of the present research, however, await further efforts, some of which are presently being undertaken. One issue is the amount of time necessary to develop effective mnemonic materials. Given that appropriate mnemonic materials are available, and that teachers have access to them, there seems to be little value in withholding them from students. However, to date, we have developed mnemonic materials appropriate for perhaps less than one fourth of the chapters presented in U.S. history, and two chapters each of science and state history materials. It appears that comprehensive materials development is not a present reality, and may not be a reality for several years to come. In this case, it seems that teachers, or students, or perhaps some combination of teachers and students will need to develop appropriate mnemonic strategies. In addition to the Mastropieri *et al.* (1988a) report, some preliminary evidence in this area recently has emerged. Mastropieri *et al.* (1988b) taught mildly mentally handicapped students information about the parts of the eye and ear, using teacher-prompted and guided-group responses to strategy questioning. Although this investigation was limited methodologically (and therefore not included in Table I), it was observed that these students were able, with prompting, to generate their own mnemonic images, and incorporate them in learning important information. In addition, their scores on this unit were higher than unit scores both immediately preceding and immediately following the eye and ear unit. Additionally, Mastropieri and Plummer (1988) reported that a mainstream high school teacher was able to recruit a student artist to draw mnemonic pictures and obtain the cooperation of a regular education high school history teacher in successfully implementing the materials.

Further research in this area would be helpful in determining how easily teachers can use their existing resources and ingenuity to facilitate mnemonic materials development. However, it seems that intensive training in this type of materials development may be necessary. In a recent undergraduate "methods" class, one of us recently gave her class as an assignment the mnemonic adaption of the "important" information from a secondary level science text. Students were asked to describe the level of meaningfulness and concreteness of the content and develop mnemonic elaborations to facilitate learning and recall, but pictures were not required. When the assignment was handed in one week later, not only were most elaborations judged to be inadequate, it was found that there was wide disagreement regarding what information was "important," and whether or not it was likely to be familiar to LD adolescents. Furthermore, every student rated the task as "difficult" or "very difficult" on a survey. Clearly, the optimal means by which teachers can acquire facility in materials development remains to be uncovered.

There is also reason to be optimistic regarding professional development of mnemonic learning materials. It is true, of course, that the development of such materials is time-consuming; but the development of any curriculum materials is time-consuming. This would be less of a problem if an increasing market demand were to make mnemonic materials more attractive to major publishers. It is also true that, once developed, mnemonic materials can be used again and again.

Transfer

Another important issue is that of independent transfer of mnemonic strategies. Successful transfer of the keyword method has been reported in average (Pressley and Dennis-Rounds, 1980) and "gifted" learners (Scruggs and Mastropieri, 1988; Scruggs *et al.* 1987a). And, in fact, some trained independent use of the keyword method by LD students has been reported in the literature (McLoone *et al.*, 1986). However, the issue of spontaneous, general transfer of a variety of mnemonic strategies is much more complicated, and much less likely to be easily realized (Mastropieri and Scruggs, 1987). In such instances, what is required is that, first, learners are able to *read* the text and determine what is "important" to remember. Next, learners determine what type of mnemonic strategy is called for (based on knowledge and attribution of strategy effectiveness) and correctly recall and implement the appropriate steps of strategy adaptation. Finally, learners need to self-test their acquisition of their information, monitor their studying accordingly, and correctly *apply* learned information in the appropriate test-taking situation (Scruggs and Mastropieri, 1988b). Given the long and well-annotated history of transfer failure in special populations (e.g., Scruggs and Mastropieri, 1984), as well as our own previously described experience with training mnemonic strategy development with college undergraduates, it seems to us that this goal will present unique challenges for future research.

Nevertheless, there are at least two reasons to be optimistic. First, there are objections to the notions that general, spontaneous transfer is the final arbiter of strategy utility. Loper and Hallahan (1982), for example, reported, "we are alarmed at what we perceive to be a tacit premise that if instruction results in generalizable results, then, and only then, was the instruction adequate" (p. 64). It is of educational importance, for example, that students with learning handicaps have acquired important information in such domains as history and science, regardless of whether strategy transfer has occurred. To this extent, special-education teachers are ethically obligated to use the most effective procedures available to insure that instructional objectives are met. And although generalized use of complex mnemonic strategies may be desirable, and is certainly worthy of further research efforts, it should be remembered that mnemonic instruction has as much to do with how teachers should teach as it does with how learners should learn (Pressley *et al.*, 1989). If future research demonstrates that LD or other mildly handicapped students can be trained to generally apply mnemonic procedures to enhance their independent learning, it would represent a breakthrough in special education. However, until such a time, there is still great potential for the application of what is presently known at this time about mnemonic instruction.

The second cause for optimism is the fact that independent mnemonic strategy use may not be an "all or nothing" issue. We have noted, in the literature, what might be characterized as a paradox of strategy transfer in special education: the less effective a strategy is likely to be, the more likely it is to achieve transfer. That is, rehearsal frequently has been identified as a relatively ineffective strategy for facilitating recall of associative information (Martin *et al.*, 1985; Rohwer *et al.*, 1977; Scruggs and Mastropieri, 1986); nevertheless, rehearsal appears to be the easiest strategy in which to induce transfer, at least to related tasks. Similarly, category clustering, although of little practical use in most school learning situations, has been shown to transfer to similar tasks with minimal instruction (Gelzheiser, 1984). On the other hand, mnemonic strategies, which typically produce large, positive effects on a variety of school-relevant learning tasks, have not been seen to transfer except under very highly structured circumstances (McLoone *et al.*, 1986). In fact, in a recent implementation, Mastropieri and Scruggs (1989a) reported finding no observable spontaneous transfer, even after six weeks of mnemonic instruction. Nevertheless, if this strategy could be simplified to some extent, and coupled with more intensive, extended training, it is altogether possible that some elements of the strategy could transfer to independent learning tasks. It is also true that all populations, to some extent, have exhibited difficulty with strategy transfer, but that many of these difficulties have been overcome with systematic training (Borkowski *et al.*, 1987).

We have described our reconstructive elaborations approach with respect to what we consider its most important underlying variable, *meaningfulness*. Meaningfulness, in its many manifestations, plays a significant role in learning (Glover and Bruning, 1988). Information made more meaningful is better remembered, even if it is not effectively elaborated with its response. For instance, in learning the paralog pair MEARDON-ZUMAP, learners who reported simply, "I saw the *ear* in meardon," were more likely to provide the correct response than those who reported simple rehearsal strategies (Martin *et al.*, 1965; Scruggs and Cohn, 1983), although overall performance for such a strategy resulted in lower levels of learning than strategies that efficiently elaborated meaningful reconstructions of stimulus and response. Nevertheless, it seems possible that LD learners could be prompted to think of ways to make unfamiliar information more meaningful (e.g., "What does 'prohibition' remind you of?" "What does 'hegemony' sound like?"). Such prompted strategies could be expected to lead to higher levels of learning. In addition, they may prove to be easy to implement and could, over time, be expected to transfer to independent learning tasks. Further research, of course, is needed to support such a hypothesis. At this point, however, we feel confident that mnemonic instruction can substantially improve the academic performance of mildly handicapped learners.

ACKNOWLEDGMENTS

Preparation of this manuscript was supported in part by grants (G008730144-88 and H029D80034) from the U.S. Department of Education,

Special Education Programs. The authors thank John Glover, Mike Pressley, and the anonymous reviewers for their feedback on an earlier version of this manuscript.

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Appendix G

Mastropieri, M.A., & Scruggs, T.E., (1989b). Mnemonic social studies instruction: Classroom applications. Remedial and Special Education, 10, 40-46.

RASE Feature Article

Mnemonic Social Studies Instruction: Classroom Applications

Margo A. Mastropieri and Thomas E. Scruggs

Seventeen mildly handicapped elementary grade students from three special education classes were taught information relevant to two chapters from a social studies textbook. All students received mnemonic instruction for one chapter, and more traditional, textbook-based instruction for the other chapter. Chapter order and experimental condition were counterbalanced to control for possible influences from order of presentation or chapter difficulty. Each chapter was taught daily over a period of 1 week, in each of the three classrooms. Chapter tests were given at the end of the week (immediate) and 1 week later (delayed). Analysis of the results revealed that under mnemonic instruction conditions, students performed significantly (and substantially) higher on both immediate and delayed chapter tests than under traditional instruction conditions. Implications for mnemonic instruction of mildly handicapped students are discussed.

IN RECENT YEARS, research has provided support for the effectiveness of mnemonic (memory-enhancing) strategy instruction for mildly handicapped students (see reviews by Mastropieri, Scruggs, & Levin, 1985, 1987b; Scruggs, Mastropieri, & Levin, 1987). Mnemonic instruction differs from more traditional methods of instruction in that teachers not only describe and highlight important information, but they also provide (or ask students to generate) specific strategies for later retrieval of that information. For example, in a study by Veit, Scruggs, and Mastropieri (1986), learners were provided with scientific root words and their meanings (e.g., *ptero-*, meaning *winged*). In the mnemonic instructional condition, learners also were provided with a specific strategy to facilitate later retrieval; in this case, a meaningful, acoustically similar keyword for the unfamiliar *ptero-*, *tire*, and an interactive picture linking keyword and response — a picture of a tire with wings. Learners were then told, when asked the meaning of *ptero-*, to think of the keyword (*tire*), think back to the picture of the tire, remember *what else* was in the picture, and retrieve the response, *winged*.

Such mnemonic instruction has had powerful effects on the amount of information mildly handicapped students can learn and remember. Research documenting these procedures has provided important implications for the instruction of learners who have been commonly characterized as exhibiting deficits in memory (Swanson, 1987). Nevertheless, many questions regarding mnemonic instruction are only beginning to be addressed. Most mnemonic instructional research reported to date has been limited in that the intervention has typically been delivered by researchers in settings removed from the special education classroom (e.g., Mastropieri, Scruggs, & Levin, 1987a; Scruggs, Mastropieri, Levin, & Gaffney, 1985; Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1987); an exception is a study by Condus, Marshall, and Miller (1986), in which mnemonic vocabulary instruction was provided in classrooms. Furthermore, instructional materials have typically been designed to serve specific research purposes, such as the keyword–pegword investigation of Mastropieri, Scruggs, and Levin (1986). Given that mnemonic strategies have been demonstrated to be effective in laboratory like settings, the level of adaptability of mnemonic strategy instruction to actual classroom content (such as science and social studies) implemented by special education teachers has become an issue of major importance (Pressley, Scruggs,

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& Mastropieri, in press), and has recently begun to be explicitly studied (Mastropieri & Scruggs, 1988b).

Mnemonic instruction, such as the keyword method, is effective because it provides an explicit link between unfamiliar information and familiar, meaningful information, such as in the *ptero-* example, above. However, not all information to be learned in school fits into the category of unfamiliar or nonmeaningful information. Mastropieri and Scruggs (in press) recently described a model of "reconstructive elaborations" in which stimuli could be classified with respect to levels of meaningfulness (or familiarity) and concreteness. Thus, responses to familiar stimuli (e.g., that World War I trenches were unhealthy) can be reconstructed to representative pictures that depict stimulus and response information. In this case, a picture of sick soldiers in trenches can be provided in a *mimetic*, or representational, picture. For information that is familiar but abstract, *symbolic* reconstructions are appropriate, for example, a church can be shown to symbolize religion (Paivio, 1971). Finally, *acoustic* reconstructions, using the keyword method, are appropriate when information is nonmeaningful or unfamiliar (to the learner), as in the *ptero-* example, above.

Of course, meaningfulness and concreteness are continuous variables, and do not always lend themselves to discrete classification. Nevertheless, Scruggs and Mastropieri (in press) provided some evidence that mnemonic instructional materials could be developed according to the model of reconstructive elaborations, and that such materials could result in substantial improvement in learning with mildly handicapped adolescents, at least when administered by trained researchers in one-to-one teaching situations.

The following research study is one of several designed to test the classroom utility of mnemonic instruction via the model of reconstructive elaborations. In this investigation, three special education teachers agreed to implement mnemonic instructional materials to teach information based upon two chapters of their assigned social studies textbook. In order to avoid problems frequently encountered in such implementation studies (such as nonequivalence of comparison groups, confounding due to classroom or teacher effects, and attrition), we employed a counterbalanced crossover design in which each student acted as his or her own control by participating in both mnemonic and traditional, textbook based conditions. Each teacher instructed two groups of students. One group from each teacher received the first chapter via mnemonic instruction and the second chapter via traditional procedures, while the reverse order was used for the second group. Since an equivalent number of students received mnemonic instruction for each chapter, the relative chapter difficulty could not become a potentially compromising factor. Finally, for two of the three classrooms, a delayed recall test was administered, in order to evaluate any effects of mnemonic instruction on long term retention.

Method

Subjects

Subjects were 17 mildly handicapped children attending special classes in three elementary schools in small towns in the Midwest. The 11 boys and 6 girls had an average chronological age of 11 years, 6 months (SD = 17 months), and were enrolled in Grades 3 through 7, including 6 third graders, 4 fourth graders, 2 fifth and 2 sixth graders, and 3 seventh graders. Fourteen of the students had been classified learning disabled (LD), and three had been classified mildly mentally handicapped (MMH) by their respective schools, using federal and state criteria. Average Wechsler Intelligence Scale for Children–Revised (WISC-R) (Wechser, 1974) IQ was 86.25 (SD = 11.8). Average reading and math grade equivalents, as assessed by the Wide Range Achievement Test–Revised (WRAT-R) (Jastak & Wilkinson, 1984) were 3.4 (SD = 1.5) and 3.6 (SD = .94), respectively. At the time of this investigation, students had been enrolled in special education programs for an average of 3 years (SD = 22 months) and were attending an average of 4.6 out of 6 (SD = .548) periods of special education per day.

Materials

Traditional, Textbook-Based Condition. Materials used in this condition were taken from the assigned textbook, *Indiana Yesterday and Today* (Crump & Pounds, 1985), chapters 9 and 10. Chapter 9, "Crossroads of America," was primarily concerned with the history of transportation in Indiana and dealt with such topics as the history of roads, bridges, and vehicles, and different historical means of travel by water, air, and space. Chapter 10 was entitled, "Indiana Natural Resources" and was primarily concerned with ore, soil, and minerals, farms, forests, and animals, and climate. Materials for the textbook based condition for these two chapters included the textbook itself and accompanying worksheets taken from published worksheet masters.

Mnemonic Instruction Condition. Mnemonic materials were developed to parallel the information presented in the textbook. Important information from the text, worksheets, and test items was adapted to mnemonic presentation. For each major piece of information, a mnemonic picture, presented on an 8½ in. by 11 in. transparency for overhead projection, was developed. In addition, a scripted, 100- to 200-word presentation was developed that summarized the information presented in the text. Twenty three mnemonic pictures and accompanying scripts were developed for chapter 9, and 22 mnemonic pictures and accompanying scripts were developed for chapter 10. Additionally, teachers also had available the textbook and worksheets used in the traditional condition.

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In developing the mnemonic materials, an attempt was made not to be selective, but to develop materials for all highlighted information presented in the text, without regard for the degree to which the information apparently lent itself to mnemonic adaptation. In developing the materials, the model of reconstructive elaborations was employed, in which levels of concreteness and meaningfulness (i.e., for the target learners) were considered in developing mnemonic pictures. Perhaps because of the nature of the information included in the two chapters, little about abstract information was presented, such that symbolic reconstructions, described above, were not necessary. However, both mimetic (representational) and acoustic (keyword) reconstructions were employed. For example, chapter 9 provided information that early bridges built by pioneers were made of material that often rotted and washed away. Since such terms as *bridge* and *pioneer* were thought to be familiar to learners, no keyword-type reconstructions were made. Instead, a mimetic picture was developed of an early pioneer standing in front of a bridge that was washing away (see Figure 1). The accompanying script stated the following:

> Sometimes early roads had to cross rivers or streams. To get to the other side of the rivers and streams, settlers built bridges. These early bridges were often made of logs or boards that rotted or washed away.
>
> To remember about early bridges, remember this picture of a pioneer standing in front of a bridge that is washing away. The pioneer is saying, "Dang! These early bridges are no good!" (Question)

For another example, chapter 9 presented information about early pioneer trails called *traces*. Since the word *trace* was thought likely to be unfamiliar to students, an acoustic reconstruction was made, whereby a meaningful keyword proxy, *race*, was shown in an interactive picture with an early pioneer trail (see Figure 2). The accompanying script read as follows:

> Indiana has gone through many changes over the years. From 1800 to 1850, during the Pioneer Age, people traveled by way of narrow trails. These narrow trails were also known as traces. Since this was how most people traveled, the Pioneer Age was also called the Age of Trails and Traces. To remember that a trace is a narrow trail that pioneers traveled, think of the keyword for trace: Race. (Question)
>
> Remember this picture of early pioneers having a race down a narrow trail. The sign says, "Annual Trace Race." One pioneer is saying, "Don't crowd, the trace is narrow", another says "Get out of my way!" Another pioneer is close to the finish line. This will help you remember that a trace (race) is a narrow trail that pioneers traveled on. (Question)

Tests. Multiple choice tests were developed for each chapter that covered all important information. An example test item from chapter 9 is given below.

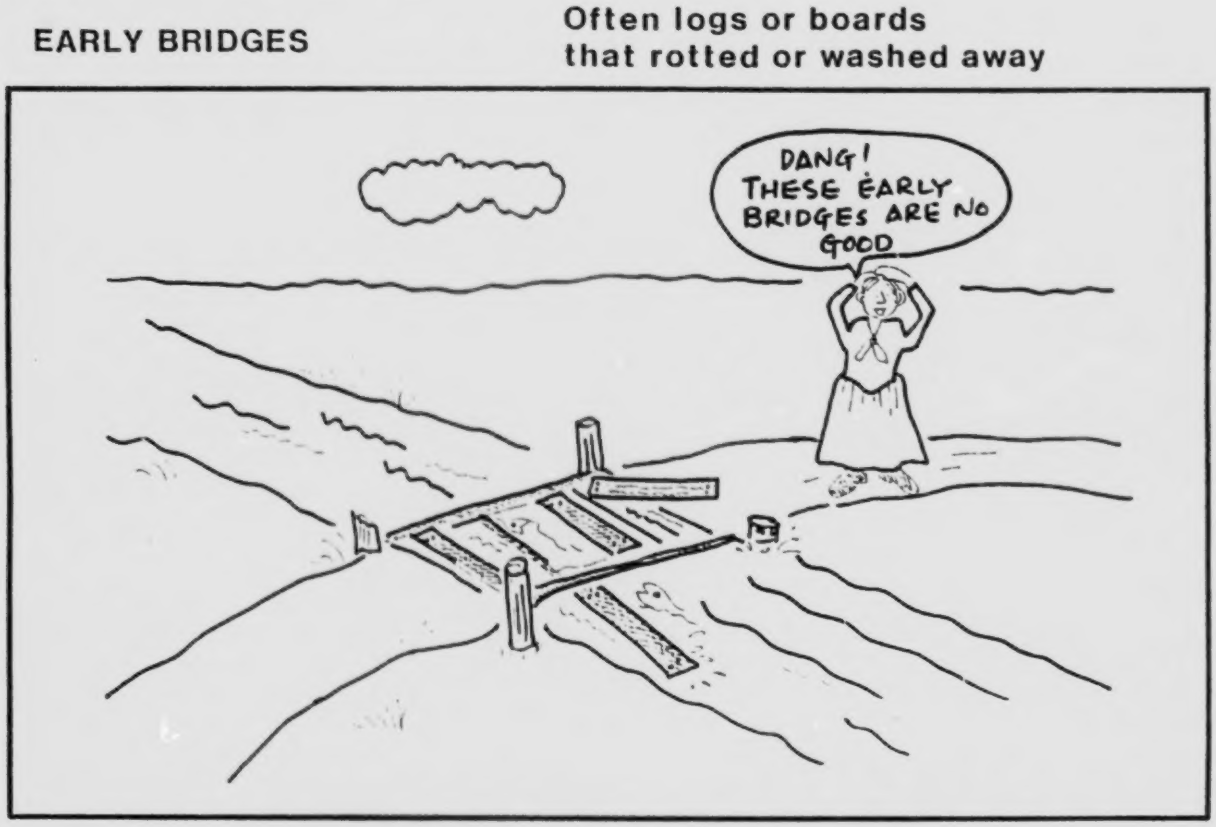
EARLY BRIDGES
Often logs or boards that rotted or washed away
DANG! THESE EARLY BRIDGES ARE NO GOOD

Figure 1. Mimetic reconstruction of "early bridges" example.

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5. A trace that pioneers used was:
   a. a vehicle
   b. a road made of logs
   c. a covered wagon
   d. a narrow trail

Chapter tests were the same for both conditions, and were the same for both immediate and delayed recall measures.

Procedure

Each of the three teachers met individually with project staff and practiced both mnemonic and traditional instructional procedures until it was determined that the procedures were mastered appropriately. During the actual implementation, all three teachers were monitored by project staff to facilitate implementation fidelity. Treatment order was counterbalanced, such that all three teachers taught both chapter 9 and chapter 10 via mnemonic and traditional methods. For example, since each teacher taught two groups of students, one group received mnemonic instruction for chapter 9 and traditional instruction for chapter 10, while the other group received traditional instruction for chapter 9 and mnemonic instruction for chapter 10. Teachers were shown chapter tests ahead of time, and told to stress the content that would be asked on the test, regardless of condition. Additionally, teachers were encouraged to employ principles of effective instruction, as described by Mastropieri and Scruggs (1987), regardless of condition. These principles included daily reviewing, providing new information, questioning and providing feedback, providing practice, and conducting formative evaluation. Procedures specific to each condition are described below.

Traditional Textbook-Based Condition. Teachers were told to read the textbook information with the students and practice with them the targeted information. After questioning and discussion, teachers were asked to use published worksheet materials as needed to reinforce learning.

Mnemonic Instruction Condition. Teachers were told to show each overhead, present the accompanying scripted information to the students, and question them regarding both content and retrieval strategies (e.g., "What is a trace?" "Who can tell me how you remember what a trace is?"). Teacher-directed practice activities, as in the traditional instruction condition, were also provided as needed.

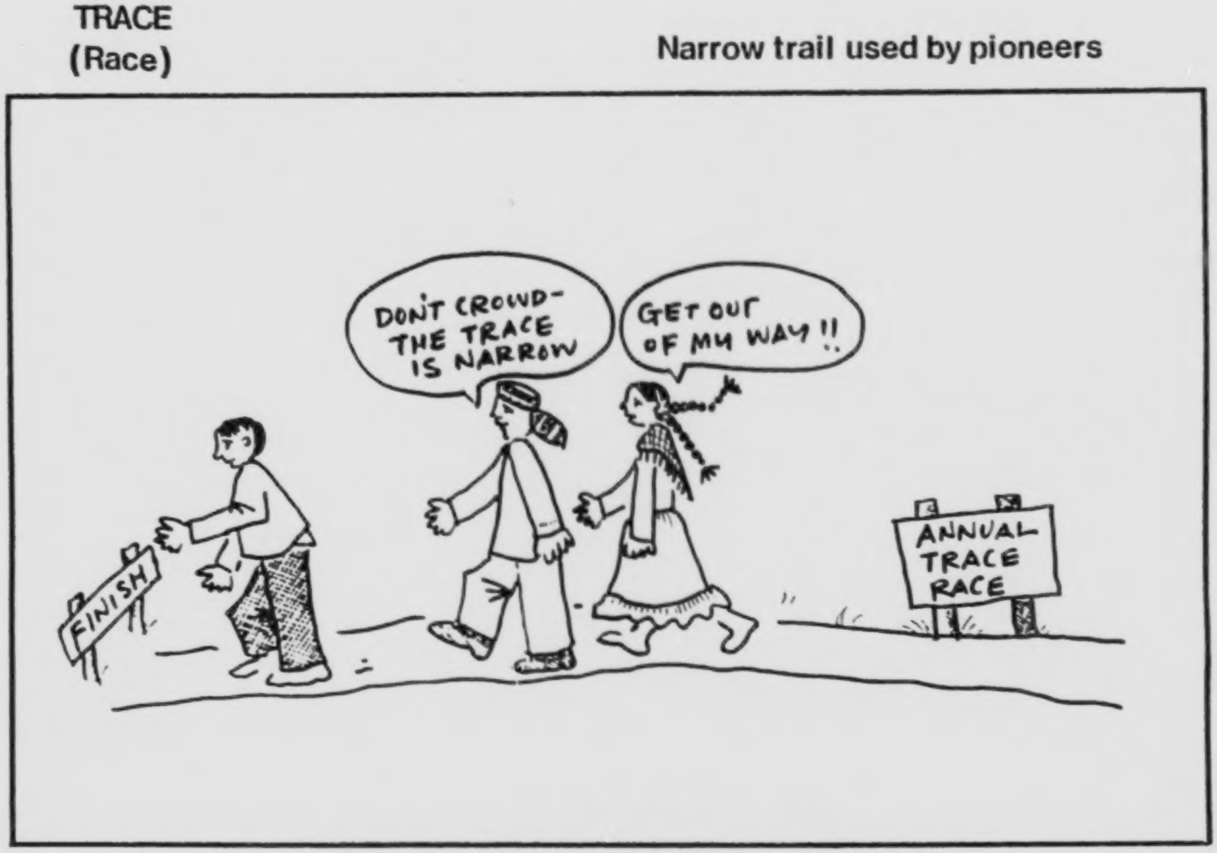
TRACE
(Race)
Narrow trail used by pioneers
DON'T CROWD- THE TRACE IS NARROW
GET OUT OF MY WAY !!
FINISH
ANNUAL TRACE RACE

Figure 2. Acoustic reconstruction of "trace road" example.

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Both Conditions. Teachers provided the same amount of time in instruction in either condition. For each chapter, sixth- and seventh-grade students were provided with five approximately 30- to 40-minute lessons on the content. Since the two classes of younger students (third to fifth grade) were expected to acquire the information more slowly, they were given 7 days of instruction per chapter. Overall, however, each student, regardless of age, received the same amount of instructional time under each condition. On the day following the last day of instruction for each chapter, students were given a chapter test. Each chapter test was also administered 1 week after the weekly test was given.

After administration of all recall measures, students were given a consumer satisfaction survey in which they were asked their opinion of the mnemonic instructional materials and the degree to which these materials had helped them learn. Additionally, the three teachers were given a survey in which they were asked their opinion of the mnemonic materials.

Results

Test scores were converted to percentages. Individual subject data are given in Table 1. Since each student had a mnemonic and a traditional condition score, these scores were compared across chapters by *t* tests for correlated means. Overall, students scored an average of 89.9% correct (*SD* = 11.0) under mnemonic instruction and an average of 74.9% (*SD* = 14.0) correct under traditional instruction, on the weekly tests. These mean differences were statistically significant, $t(16) = 4.81$, $p = .000$. These differences were also seen to be reasonably consistent across classrooms, with students in each classroom scoring higher under mnemonic instruction. Mean differences in percentages for the three classrooms were 18.0, 17.3, and 10.3.

Table 1. Recall Scores by Subject

		Immediate Recall		Delayed Recall	
Teacher	**Subject**	**Mnemonic**	**Traditional**	**Mnemonic**	**Traditional**
1	1	100	87	95	70
1	2	100	83	95	70
1	3	100	65	100	70
1	4	91	74	96	84
1	5	87	79	96	79
2	6	91	100	91	86
2	7	87	74	65	59
2	8	91	68	61	59
2	9	100	96	95	91
2	10	95	65	64	48
2	11	95	52	95	65
3	12	90	79	—	—
3	12	57	47	—	—
3	14	81	84	—	—
3	15	95	74	—	—
3	16	74	63	—	—
3	17	95	83	—	—

One teacher was unable to administer the delayed recall test, due to absences and scheduling problems near the end of the school year, when this investigation was conducted. The 11 students who did take the delayed recall test, however, scored 86.6% (*SD* = 15.1) correct under mnemonic instruction and 71.0% (*SD* = 13.1) correct under traditional instruction. These differences were also statistically significant according to a *t* test for correlated samples, $t(10) = 4.88$, $p = .001$.

Consumer satisfaction surveys suggested that students both enjoyed using the materials and appreciated their value in facilitating learning. Of 17 students surveyed, 16 reported that they liked using the pictures, 17 agreed that the pictures had helped them learn more information. Sixteen reported that they liked using mnemonic materials better than what they usually did in class; and all 17 students reported they received higher grades on history tests when taught mnemonically. Finally, 16 students reported that they would like to use mnemonic materials in other content areas and mentioned a variety of subjects, including science, social studies, language, math, health, and reading.

All three teachers reported that they had enjoyed using the mnemonic materials, and that the materials had been easy and convenient to use. All teachers agreed that their students had enjoyed using the mnemonic materials, were more motivated to learn, and learned more content when using the mnemonic materials.

Discussion

The results of the present investigation suggest that social studies content can be adapted to mnemonic instruction via the model of reconstructive elaborations, and can result in a sizable performance advantage over more traditional, textbook based approaches. This is of particular importance to students characterized as LD or MMH, as both research results and common knowledge of special education teachers reveal that memory for associative information is a particular weakness of these populations -- a weakness that explains a considerable amount of school failure. Various theories have been put forward to explain memory deficits of mildly handicapped students (see Scruggs, 1988, and Swanson, 1987, for reviews); nevertheless, what appears to be needed in many cases is the establishment of an efficient retrieval route between stimulus (the question) and response (the answer). The results of this and previous investigations seem to suggest that mnemonic instruction is uniquely qualified for this purpose.

This investigation also parallels other concurrent, and as yet unreported, research (e.g. Mastropieri & Scruggs, 1988), in which special education teachers have successfully conducted extended units of mnemonic instruction. Results of these investigations to date suggest that a variety of social studies content domains can be adapted to mnemonic instruction and that such adaption can be expected to result in substantial gains in the academic

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performance of mildly handicapped learners in both elementary and secondary schools.

One unique feature of mnemonic instruction (and, perhaps, a limitation) is that it is content bound. That is, effective mnemonic instruction can result only from a careful consideration of the content to be learned, and a sometimes painstaking development of mnemonic elaborations and materials. To this extent, it seems likely that teaching mildly handicapped students to develop and apply independently complex mnemonic reconstructions will be a challenging prospect, at best, particularly as compared with training of much simpler (but also much less effective) strategies such as rehearsal and clustering. Although LD students have been trained to transfer the keyword strategy to vocabulary lists (McLoone, Scruggs, Mastropieri, & Zucker, 1986), and gifted students have been seen to spontaneously transfer even more complex strategies (Scruggs & Mastropieri, in press), it seems plausible to assume that, at present at least, mnemonic instruction of mildly handicapped learners will require materials development on the part of the teacher. It should be remembered, however, that materials need only be developed once, and that many teachers find themselves teaching the same content (e.g., state history) over a period of years. It has also been seen that teachers who lack artistic skills can develop effective mnemonic materials using stick figures and cut outs from magazines (Mastropieri, Emerick, & Scruggs, in press).

Overall, research evidence suggests that mnemonic instruction is a versatile and efficient means of improving the learning of mildly handicapped students. Nevertheless, questions remain to be addressed, and are currently being examined by the present authors. These questions include (a) the extent to which mnemonic instruction can positively impact upon more abstract or conceptually oriented content, such as that found in the earth or physical sciences, (b) the extent to which mnemonic instruction can facilitate acquisition of basic skills, such as reading, math, and language arts, and (c) the extent to which mildly handicapped students can learn to generalize mnemonic strategies to other academic content. The evidence to date, however, suggests that mnemonic instruction will prove to be a truly "special" technique for special education.

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Authors' Note

1. Research reported in this manuscript was supported in part by a grant from the U.S. Department of Education, Special Education Programs, No. G008730144-88.

2. The authors thank Julia Gilstrap, Susan Evans, and Dorothy Krueger, for their assistance.

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Appendix H

Mastropieri, M.A., & Scruggs, T.E. (1989c). Reconstructive elaborations: Strategies for adapting content area information. *Academic Therapy*, *24*, 391-406.

RECONSTRUCTIVE ELABORATIONS: STRATEGIES FOR ADAPTING CONTENT AREA INFORMATION

Margo A. Mastropieri
Thomas E. Scruggs

Presents techniques for assisting students in remembering content area material by designing pictorial formats that are meaningful and familiar.

The present paper describes a model for developing pictures to increase recall for content area information. It has recently been recognized that when pictures are constructed to accompany specific content area instruction, students can learn twice as much information. The pictures, unfortunately, are not the ordinary type of pictures found in school textbooks. In the Reconstructive Elaborations model, Scruggs and Mastropieri (in press) have constructed pictures following specific procedures. This model has been validated by recent research with exceptional populations demonstrating that these memory enhancing pictures, when supplied by teachers, can increase student learning on initial tests as well as delayed recall tests in many content areas. This technique relates closely to the study skills area, as it has been found to enhance the learning of science concepts (Mastropieri, Emerick,

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& Scruggs, in press); abstract and concrete English vocabulary (Mastropieri, Scruggs, & Fulk, in press); U.S. history (Mastropieri & Scruggs, in press-a; Scruggs & Mastropieri, in press); and social studies content, including information on transportation and natural resources (Mastropieri & Scruggs, in press-b). Scruggs and Mastropieri (in press) have grounded the model in learning theory and have provided validation data supporting it.

The primary goal of this paper is to define and describe the Reconstructive Elaborations model. Specific examples are provided from a social studies content area. Finally, a description of how teachers can integrate these memory enhancing pictures within an effective instructional format is presented.

Reconstructive Elaborations: The Model

Reconstructive elaborations are intended to make *unfamiliar* content *familiar*, and to make *nonmeaningful* information *meaningful* for learners. Research evidence suggests that when information is both familiar and meaningful to learners, it is more memorable. Reconstructive elaborations are therefore developed with respect to levels of familiarity and meaningfulness of the content, in relationship to the target learners.

Both the components, "reconstructive" and "elaborations," play important roles in the development of the strategic pictures. *Reconstructive* refers to the process used to reconstruct, or modify, information to a more familiar and a more meaningful form. *Elaborations*, on the other hand, refer to the process of linking critical pieces of information together. Both components work simultaneously to assist learners in more effective encoding of information, which, in turn, facilitates retrieval of the information on immediate as well as delayed recall measures.

For example, to remember that "deciduous trees shed their leaves in the fall," learners are first taught a reconstructed keyword term for *deciduous*, which is a familiar, meaningful, and acoustically similar term. In this case, *decide* would be a good reconstructive term because *decide* is a word that is familiar and meaningful to learners, and it sounds like *deciduous*. Next, learners are shown an interactive illustration that contains the reconstructed term (*decide*) in an elaboration with the to-be-remembered information (trees that shed leaves in the fall). A good example would be a picture of a deciduous tree saying, "It's cold, I'll *decide* if I should drop my leaves now because I'm a *deciduous* tree," as shown in Figure 1. Following this, learners are taught the retrieval steps for obtaining the correct response. When learners are asked what "deciduous" means, they are told to think back to the reconstructed keyword for *deciduous*. Since *decide* sounds like *deciduous*, and it is already meaningful and familiar to the learners, the retrieval of this term should be easy. Next, learners are told to think back to what was happening in the interactive elaboration (picture). Since the reconstructed term was doing something with the to-be-remembered information (in this instance, a deciduous tree was deciding to shed its leaves in the fall), learners are readily able to respond with the appropriate information.

In the above example, the word *deciduous* is likely to be unfamiliar and nonmeaningful to the learners. Thus it is first reconstructed into a more familiar and more meaningful term (*decide*) that is also acoustically similar. Then, notice that the reconstructed term is placed in an elaboration in which the reconstructed term interacts with the to-be-remembered information. These steps parallel those described by Scruggs and Mastropieri (1984) in the keyword method.

Sometimes, however, information that students need to learn may already be familiar to them. In such instances, information only needs to be reconstructed pictorially for learners in order to enhance meaningfulness. For example, to remember that "evergreen trees stay green all year," learners can be taught the reconstructed pictorial representation for *evergreen tree*. In this case, since *evergreen tree* may be already familiar to the learners, a simple depiction of an evergreen tree will suffice. Notice that this time, as in the above example, the term has been reconstructed into an acoustically similar term that is familiar and meaningful, but the term has really stayed the same since it is assumed that the target population is already familiar with it. Next, the elaboration component is completed by showing learners an interactive illustration of evergreen tree with the to-be-remembered information. A good interactive elaboration would be a picture of an evergreen tree saying, "I'm always green, I'm an evergreen tree" (see Figure 1). The retrieval steps for this example parallel those described for the deciduous example above, in that learners are first told to think of the reconstructed term, and then back to the picture that contained that term. Notice that this example empha-

DECIDUOUS (Decide)
EVERGREEN (Evergreen)

Shed leaves in fall
Stay green all year

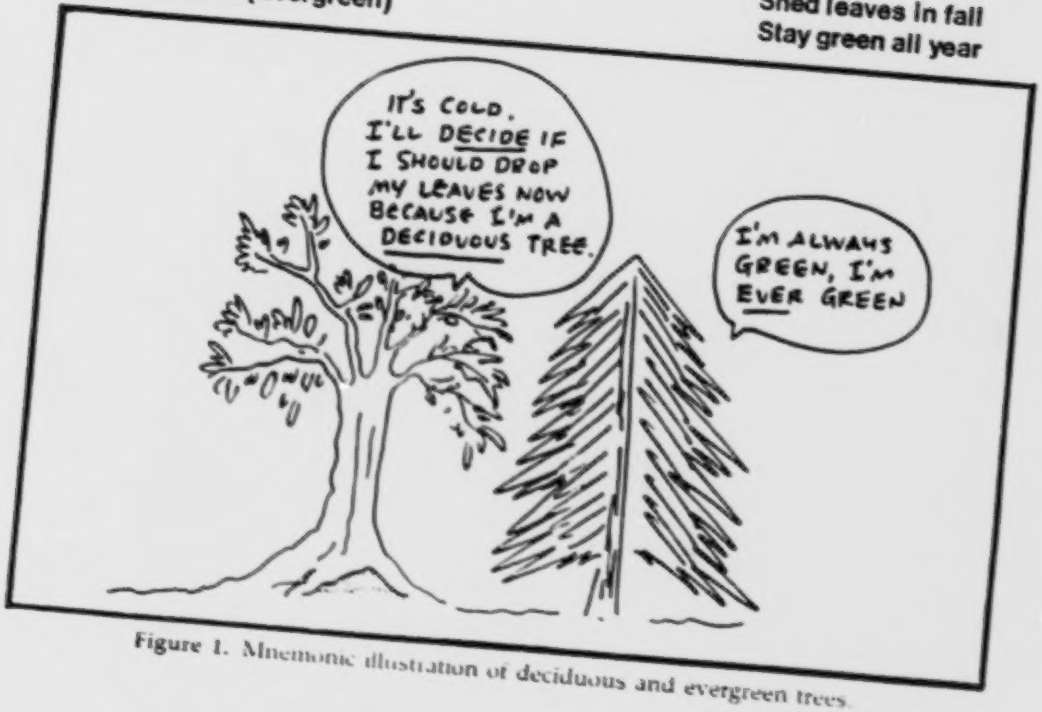
IT'S COLD. I'LL DECIDE IF I SHOULD DROP MY LEAVES NOW BECAUSE I'M A DECIDUOUS TREE.
I'M ALWAYS GREEN, I'M EVER GREEN

Figure 1. Mnemonic illustration of deciduous and evergreen trees.

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sizes and restates the relationship that already exists between evergreen tree and the important information to be recalled.

The above examples provide an initial sample of how content area information can be reconstructed to form elaborations that will help facilitate learning. The first step involves reconstructing the information into more familiar and more meaningful formats, while the second step involves creating elaborations that link the to-be-remembered parts of the content together. The next section will describe how we used reconstructive elaborations to adapt content from a social studies textbook on transportation to assist the learning of that information for elementary-aged students who were learning disabled (LD) and mildly mentally handicapped (MiMh).

Adapting Social Studies Content

First, we examined the textbooks that the teachers were using to teach the social studies content. Concurrently, we examined any corresponding worksheets and materials that teachers considered relevant and supplementary to that content. Then, we identified the critical pieces of information that were to be learned by all students. A list similar to the one below was completed for the chapter:

Terms	To-be-associated Information
1. Corduroy roads	Roads made of logs across muddy places
2. Plank roads	Roads made of split logs
3. Erode	Washed away by wind and rain
4. Cumberland Road	National Road, built with tax dollars to link the East and the West
5. Covered bridge	Bridge with a stone base and roof
6. Interstate highway	Highway between states

Following this, each piece of information in the list was examined in order to determine first, the type of reconstruction that would be necessary, and second, a good elaboration for linking the two pieces of information together. For example, since the first example, *corduroy road,* is completely unfamiliar and nonmeaningful for the learners (i.e., elementary level students who

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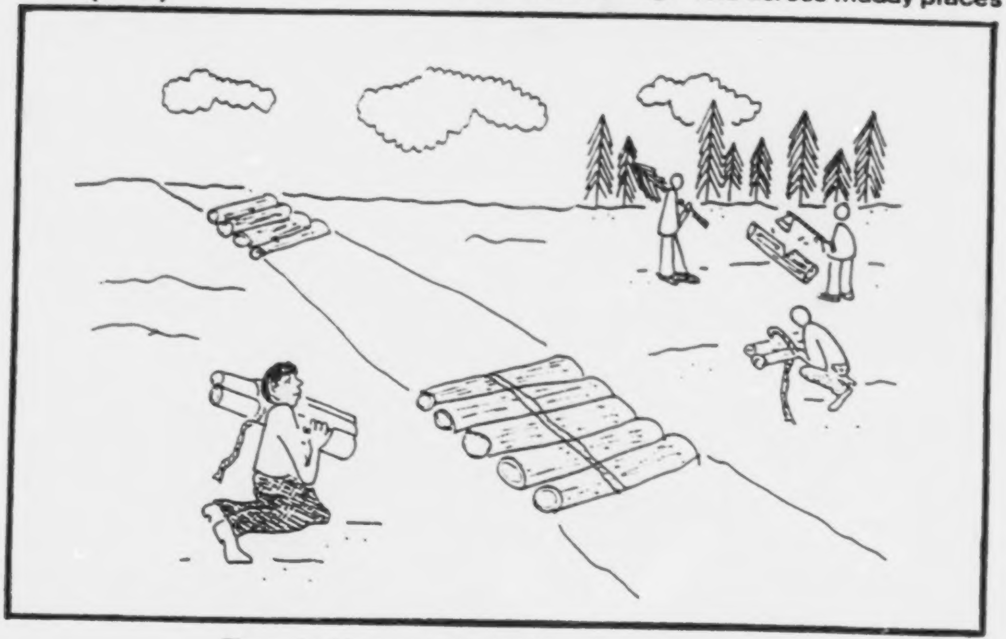
were LD and MiMh), *corduroy road* was reconstructed to the familiar, meaningful, and acoustically similar term *cord*. Then, an elaboration containing a good interaction of *cord* and "roads made of logs laid across muddy places" was developed. As can be seen in Figure 2, logs tied together with cords are being laid across a road. Notice that the picture contains only relevant information. Retrieval directions would parallel those described earlier. For example, when asked about the meaning of corduroy roads, learners would be taught to first think of the acoustically similar word, *cord*, then to think back to the picture with the cords in it, and finally to retrieve the appropriate response, "roads made with logs laid across muddy places."

In the second example, *plank* (in the term *plank road*) was thought to be unfamiliar and nonmeaningful for our target learners. *Plank* was reconstructed to the familiar, meaningful, and acoustically similar term, *plant*. Then, the elaboration of plants interacting with the to-be-remembered information was developed. In this case, as shown in Figure 3, plants were growing all around the planks in the plank road. If, however, in the present example, the term *plank* was already familiar and meaningful to the target learners, *plank* could have been simply reconstructed to a pictorial representation, as in the *evergreen* example (in other words, a picture similar to the one in Figure 3, with the plants removed).

In the third example, the term *erode* was unfamiliar and nonmeaningful to the target population. *Erode* was reconstructed to the familiar, meaningful, and acoustically similar term *road*. Finally, as shown in Figure 4, the reconstructed term *road* was depicted in the elaboration of a road that had been eroded in places from wind and rain.

In the fourth example, the term *Cumberland Road* was also totally unfamiliar to our target population. *Cumberland Road* was reconstructed to *cucumber road*, and then depicted in an interactive elaboration of people eating cucumbers along the Cumberland Road. Additionally, signs and dialogue in the elaboration emphasized that the road was built with tax dollars and that the road connected the East with the West (see Figure 5).

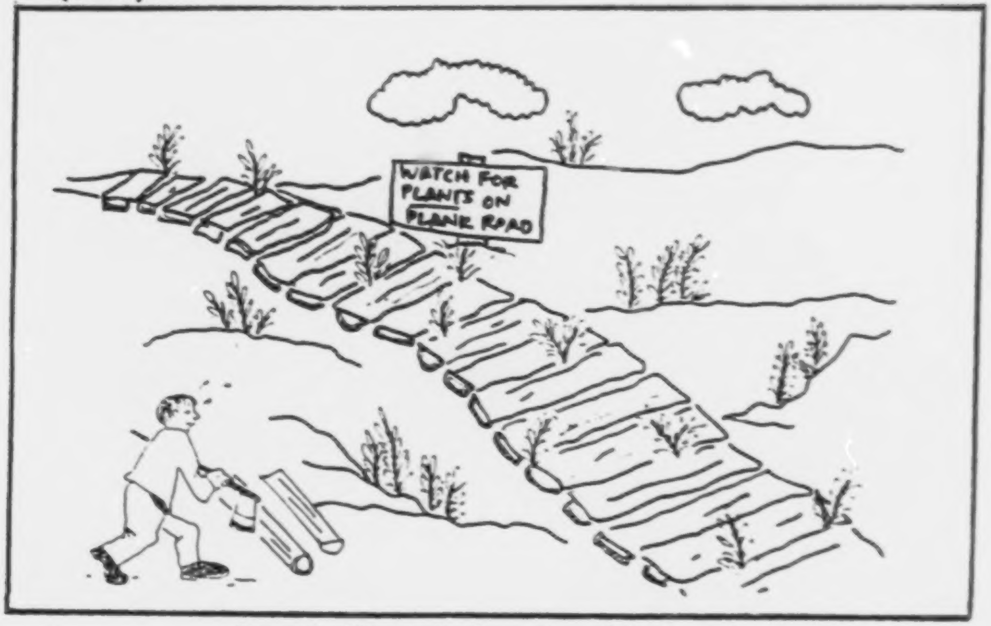
The final two examples in the list above, *covered bridge* and *interstate highway*, both contain terms that were already familiar and meaningful to the target learners (see Figures 6 and 7). Each of those terms was first simply reconstructed to the exact pictorial representations (e.g., *covered bridge* and *highway*, respectively),



CORDUROY ROAD
(Cord)

Road made of logs laid across muddy places

Figure 2. Mnemonic illustration of corduroy road.



PLANK ROADS
(Plant)

Roads made of split logs

Figure 3. Mnemonic illustration of plank road.

ERODE (Road)

Washed away by rain

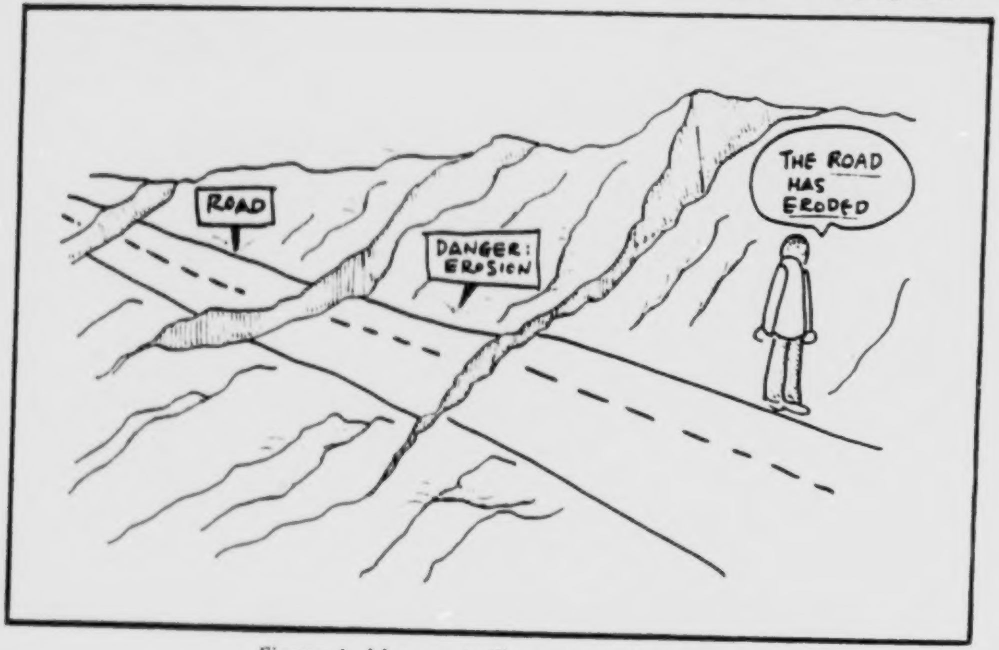


Figure 4. Mnemonic illustration of erode.

CUMBERLAND ROAD
(Cucumber)

NATIONAL ROAD
Road built with tax money to link East and West

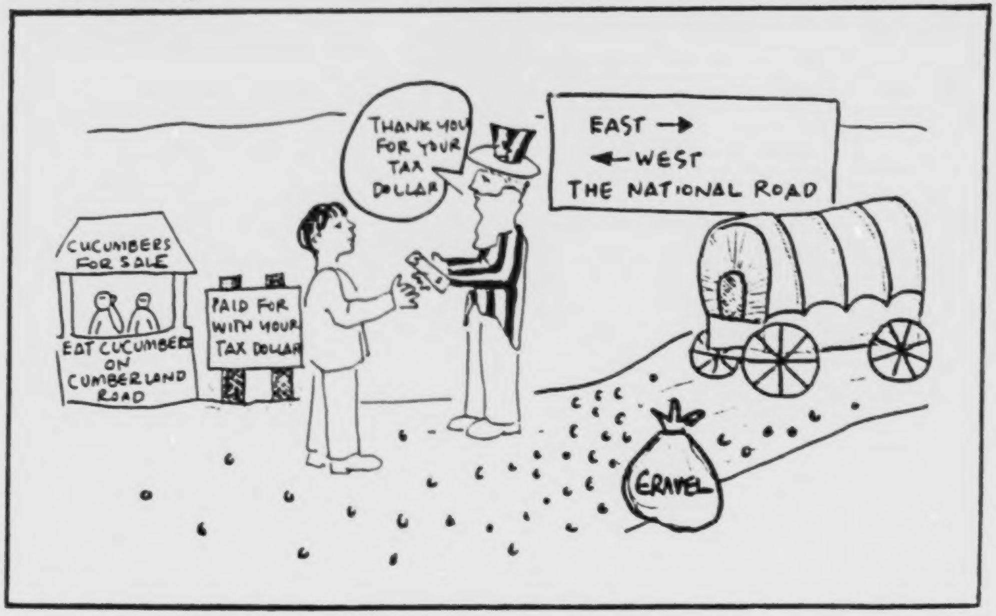

THANK YOU FOR YOUR TAX DOLLAR
EAST →
← WEST
THE NATIONAL ROAD
CUCUMBERS FOR SALE
EAT CUCUMBERS ON CUMBERLAND ROAD
PAID FOR WITH YOUR TAX DOLLAR
GRAVEL

Figure 5. Mnemonic illustration of Cumberland Road.

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COVERED BRIDGE A bridge with a stone base and a roof

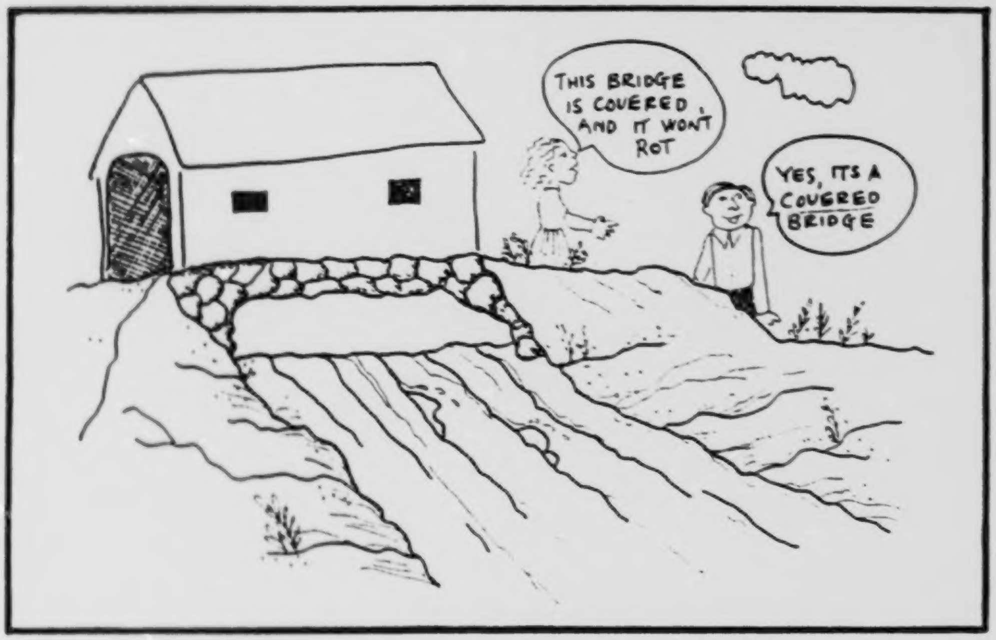
THIS BRIDGE IS COVERED, AND IT WON'T ROT
YES, ITS A COVERED BRIDGE

Figure 6. Mnemonic illustration of covered bridge.

INTERSTATE HIGHWAY A highway between states

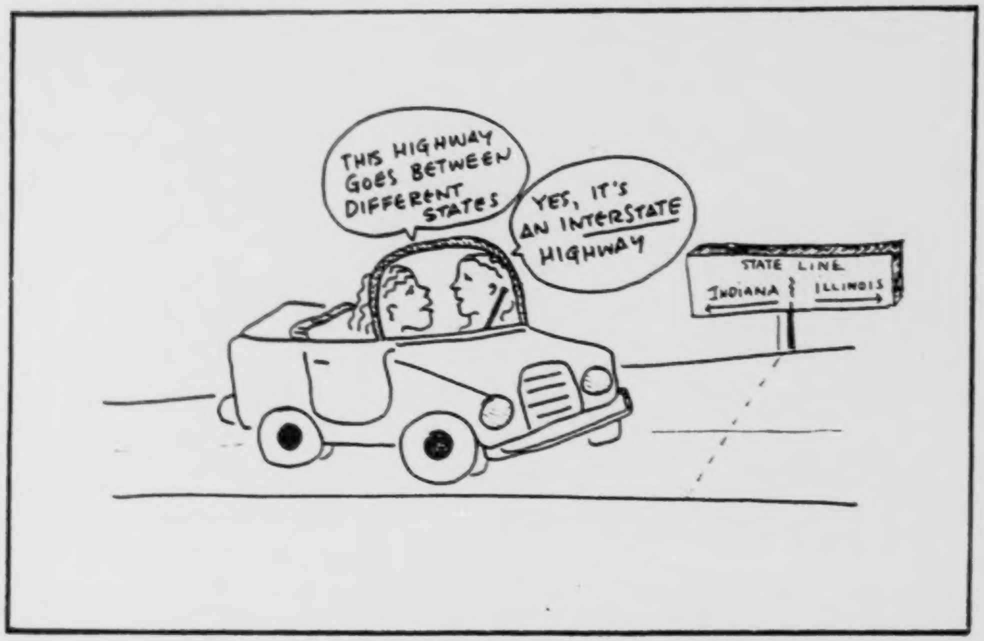
THIS HIGHWAY GOES BETWEEN DIFFERENT STATES
YES, IT'S AN INTERSTATE HIGHWAY
STATE LINE
INDIANA
ILLINOIS

Figure 7. Mnemonic illustration of interstate highway.

and then shown in appropriate elaborative interactions that linked each respective reconstructed term with the to-be-remembered information. In the context of the instruction, *covered bridge* was shown as superior to earlier bridges, which often rotted from the rain and washed away. Additionally, the relation between *interstate* and between states was made explicit.

In summary, once important pieces of information are identified, that information can be examined to determine how familiar and meaningful it is for the target population. Then, the degree to which that information needs to be reconstructed can be determined, and good elaborations that link the important pieces of information together can be generated. In our research to date we have typically generated the reconstructive elaborations (see Mastropieri, Emerick, & Scruggs, in press, however, for an exception) and given them to teachers to use. We have also made recommendations to teachers regarding the type of presentation format. This presentation format is briefly described below.

Instructional Procedures

It is recommended that teachers employ the "teacher effectiveness" variables, as described by Mastropieri and Scruggs (1987), which include the following:

1. Daily Review. Each lesson should begin with a daily review emphasizing previously covered content. Using the content covered earlier, a teacher might say, "We have been studying information about transportation. Who can tell me the name of a road in which logs were put down in muddy places?" (corrective feedback as necessary); "What other types of roads have we learned about?" (corrective feedback as necessary).

2. Statement of Objective and Teacher Presentation. Then the teacher should present a statement regarding the objective for the present lesson. For example, the teacher might say, "Today we are going to continue to learn more about transportation. We are going to learn about the first National Road that linked the eastern part of the U.S. with the western part, and we are going to learn about interstate highways and covered bridges." Following this, the teacher would first present the important informa-

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tion for the learners to remember. Using the Cumberland Road as an example, the teacher might explain that the National Road was very important to the people of the United States because it linked the eastern United States with the western United States. Then the additional important attributes associated with the National Road would be identified for learners. These attributes include that it was also referred to as the Cumberland Road, and that it was built with funds from tax dollars.

The teacher would then present the strategies for facilitating the learning of that important information. For example, while putting an overhead transparency up for group viewing, the teacher might say,

> Here is a picture that will help you remember that the Cumberland Road was also called the National Road, that it linked the East to the West, and was built with funds from tax dollars. Cumberland sounds like cucumber, so remember the keyword for cumberland is cucumber. Remember this picture of people eating cucumbers along the Cumberland Road, that the sign says National Road and that it was built with money from our tax dollars. What is the keyword for Cumberland? What was happening in the picture with the cucumbers in it? Therefore, what can you tell me about the Cumberland Road? Is it really where people sell cucumbers? (No, that's just how we remember the information.)

3. Guided Practice. Teachers can then continue to practice both the strategies and the relevant information to be remembered. Students can be questioned regarding their understanding of the content, and the teacher will thus be given feedback as to whether the content is being effectively mastered.

4. Independent Practice. Worksheets requiring students to complete items that test their understanding on the information presented can be distributed. For example, students can be required to answer questions such as, "What do you know about the National Road?" "What road was built with U.S. tax dollars?" "What was the strategy you used to remember the information on the Cumberland Road?"

5. Formative Evaluation. Teachers can administer a few items that cover the content taught during the lesson to determine whether the content was mastered, and whether that material needs to be re-presented the following day.

Summary

This paper has briefly presented the model of reconstructive elaborations applied to content area learning. The purpose of reconstructive elaborations is to make content more familiar and more meaningful for target learners and to link to-be-remembered information together. Research results to date have indicated that special education students have learned and retained twice as much information when teachers present content to them using reconstructive elaborations. It was also emphasized that the background knowledge of the learner plays a critical role in the development of these strategies, and that teachers are most effective when they employ those variables identified in the teacher effectiveness literature.

Authors' Note

Support for this paper was provided by a Research Implementation Grant funded by the U.S. Department of Education, Special Education Programs, No. G008773014-88.

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Tying a shoe is a task most of us take for granted. But for some of us, it's much more. It's an achievement.

Three out of every 100 Americans are mentally retarded. That's six million people who need our help and encouragement. Not to tie their shoes for them, but to help them learn to do things for themselves.

Through the ARC — the Association for Retarded Citizens — America's retarded citizens are learning to be self sufficient. ARC provides job training workshops, educational programs, sheltered workshops and neighborhood housing to help retarded people help themselves.

Over 85% of America's retarded citizens can lead productive lives. Even the most severely retarded people can learn to stand on their own two feet.

It's a big job. But a rewarding one. ARC needs you to give whatever you can — time, money, jobs, housing opportunity, understanding.

Next time you bend over to tie your shoes, remember those who need a little more help — and remember that you can give it.

arc
Association for Retarded Citizens
When you give help you give hope.

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Appendix I

Mastropieri, M.A., & Scruggs, T.E. (1989d). Reconstructive elaborations: Strategies that facilitate content learning. Learning Disabilities Focus, 4, 73-77.

Reconstructive Elaborations: Strategies that Facilitate Content Learning

MARGO A. MASTROPIERI
THOMAS E. SCRUGGS
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This article describes the model of "reconstructive elaborations" and summarizes the procedures necessary to implement the model. Basically, the model provides a framework for adapting all content-area information into more familiar, more concrete, interactive elaborations. Once the content has been modified using the reconstructive elaborations, learning disabled students can be taught the content with the assistance of these strategies. Recent research has demonstrated that learning disabled students immediate and delayed recall of important U.S. history content can be facilitated under instructional conditions using reconstructive elaborations.

Reconstructive elaborations are intended to facilitate the initial acquisition and delayed retention of information from content-area textbooks. Reconstructive elaborations attempt to make unfamiliar content familiar and nonmeaningful information meaningful. In addition, reconstructive elaborations link important concepts, events, and facts in content areas.

TARGET POPULATION

In our research studies to date, we have used reconstructive elaborations with learning disabled (LD) students enrolled in middle schools, junior high schools, and high schools. Because we have verbally presented the information to the LD students, we have essentially removed the onus of prerequisite decoding skills. If, however, teachers want students to read independently and execute the information, they must accommodate LD students' decoding problems and insure that the difficulty level of the materials is commensurate with students' reading skills. The readability of our research materials to date is about fourth to sixth grade. However, the target U.S. history textbooks currently adopted by school districts are on the eighth grade reading level and higher.

THE PURPOSE OF RECONSTRUCTIVE ELABORATIONS

The purpose of reconstructive elaborations is to provide an instructional model that uses several types of mnemonic systems that facilitate school learning. Reconstructive elaborations make content more *concrete* and more *meaningful* for the learner and thus increase learning. The next sections present the theoretical framework for reconstructive elaborations, followed by a thorough definition of reconstructive elaborations and finally several examples.

THEORETICAL FRAMEWORK FOR RECONSTRUCTIVE ELABORATIONS

Psychologists have studied human learning for decades and have found that the more concrete and the more meaningful information is for learners, the greater the recall of the to-be-learned information (e.g., Bower & Hilgard, 1981; Paivio, 1971; Underwood & Schultz, 1960). Much of this research has been focused on learning lists of information, including (1) long lists of nonsense syllables or numbers (serial list learning) or (2) what is commonly

Learning Disabilities Focus, 1989, 4(2), 73-77

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referred to as *stimulus-response or paired associate learning*. The latter includes learning that, for example, the stimulus "neglan" goes with the response "gokem" (Scruggs & Cohn, 1983).

Elaborative Strategies

Researchers have also documented that elaborations facilitate learning (Rohwer, 1968). *Elaborations* can be defined as additions to original information to help facilitate recall. Elaborations can take many forms, in that they may be verbal, imaginary, or pictorial. Typically the essential feature of an elaboration is the embellishment or expansion of ideas on information that is to be learned. For example, to learn the association "bird-plant," providing an elaborative picture or image of the sentence "My *bird* ate my *plant*" could be expected to facilitate learning of the associates. Most researchers have specified that elaborations will tend to be more successful at aiding recall if the elaboration *links* the stimulus with the response. Atkinson (1975) provided some very important evidence demonstrating that the linking of the information was important. Similarly, Rohwer (1968) and his colleagues demonstrated some initial positive effects with special education populations with this type of learning.

Memory and Learning Disabilities

Such strategies would appear to be ideally suited for LD students. Deficits in memory functioning are among the most widely cited characteristics of learning disabled children (Cooney & Swanson, 1987). As noted by Mastropieri, Scruggs, and Levin (1985), LD students have exhibited deficits in both short-term and long-term memory, memory search, and spontaneous use of mnemonic strategies (Pressley, Heisel, McCormick, & Nakamura, 1982; Torgesen & Kail, 1980; Worden, 1983). A recent text focuses exclusively on the issue of memory deficits and learning disabilities (Swanson, 1987).

Mnemonic elaborative strategies, then, could be useful for LD students, given that those students can meet the attentional or information-processing demands of the strategies. Some previous theories of learning disabilities might suggest that LD students might not benefit from mnemonic strategies of the type described here. For example, Harber (1980) suggested that LD students may be too distractible to benefit from pictorial information presented to accompany text. In addition, theoretical viewpoints suggesting that LD students can not integrate auditory and visual information (e.g., Kirk & Kirk, 1971) or that LD students suffer from perceptual deficits (e.g., Orton, 1937) are also not supported by results of mnemonic strategy research, at least for the large number of LD students who have participated in this research. Recent research on the keyword method and related mnemonic strategies has demonstrated that these strategies can be very effective in facilitating both immediate and delayed recall of content-area information (Scruggs, Mastropieri, & Levin, 1987).

DEFINITION OF RECONSTRUCTIVE ELABORATIONS

Reconstructive elaborations have two components. The first component is the definition of elaboration; the second component is the definition of reconstructive. Each component is critical and each is described separately below.

The Elaboration Component

When we refer to *reconstructive elaborations* (Scruggs & Mastropieri, 1988) we include the *linking component* in the definition of *elaboration*. In other words, the stimulus information must be linked with the response information. For example, in history it is fairly common to have to learn, for example, the names of people and what they are famous for, the names of events and what they are noted for, the names of countries that were on opposing sides during a war, or the names of new weapons and what effects they had in battles. If all of these examples were to have reconstructive elaborations developed for them, the stimulus information would have to be linked with the response information either in an interactive illustration, sentence, or image. The linking component appears to work best when the stimulus item can be shown to be interacting with the response item. Specifically, consider the following information paraphrased from a U.S. history text on World War I (Rawls & Weeks, 1985).

> During World War I, the armies of both the Allied and Central Powers fought much of the war from the trenches. These trenches were deep and wide enough to hide the soldiers while they were standing; however, since the soldiers had to spend enormous amounts of time in the trenches, conditions in them became very unhealthy. Consequently, many soldiers became ill and died due to those unhealthy conditions.

A good elaboration that provides an effective link between the stimulus *trench* and the response information *conditions in the trenches were unhealthy and many soldiers became ill and died there*, is a picture, sentence, or image of *lots of sick soldiers in*

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the trenches. In other words, the trench is interacting with the to-be-remembered information. In contrast, in our examination, most U.S. history textbooks simly provided a picture of soldiers in trenches, without explicit pictorial reference to living conditions. The pictures maybe of some value in enhancing motivation or interest, but by representing only half of the necessary information, are less likely to facilitate learning and long-term recall.

The Reconstructive Components

The reconstructive component assists in making the information more concrete and more meaningful for the learner. In other words, the extent to which the material needs to be reconstructed depends upon level of concreteness as well as the learner's prior knowledge. If the stimulus information is *unfamiliar* to the learner, then the stimulus must be reconstructed into something that is more concrete and more meaningful (or familiar). These reconstructive components can be, depending upon level of concreteness and meaningfulness, either mimetic, symbolic, or transformational, as described below.

Mimetic representations. The term *mimetic* refers to a literal pictorial representation of either the stimulus or response item. In the example above, the term "trench" is not only concrete, but also has been meaningful to all the LD students with whom we have worked. We therefore did not modify (reconstruct) the stimulus term "trench," but merely provided the interacting elaboration in the form of an illustration as described.

Symbolic representations. Other information presented in textbooks may not be concrete information and may not be meaningful to learners. For example, in 1914, when World War I first began in Europe, America maintained a neutral policy toward both Central and Allied Powers. Here the stimulus information (U.S. policy) is more abstract. Consequently, we *reconstructed* that stimulus information to a more concrete illustration of "Uncle Sam," to symbolize the United States. Then, to provide the elaboration, or interacting component with the response information (the notion of remaining neutral), Uncle Sam was depicted standing on a globe looking over at Europe fighting while saying, "It's not my fight." Notice that the concept of neutrality was also made more concrete and meaningful by the provision of "not fighting," something well within the prior knowledge of most LD students.

Transformational representations. Some information is completely unfamiliar to the learner, and therefore (to the learner) not concrete. That information includes unfamiliar vocabulary words and the names of unfamiliar people, places, and things. The reconstructive component can also include transforming unfamiliar words into keywords and providing the interactive component (elaboration). Our past research involving hundreds of LD students in 17 experiments has consistently documented the dramatic success that LD students experience when they are instructed to learn using the keyword method (see Mastropieri, 1988; Mastropieri & Scruggs, 1987; and Scruggs et al., 1987, for reviews).

We found that much critical information within U.S. history textbooks is unfamiliar for LD students and that the information lends itself quite easily to the development of keywords and corresponding interacting illustrations. For example, during World War I, many important people are discussed: William Jennings Bryan, George M. Conan, General Pershing, Eddie Rickenbacker, and Pancho Villa, to name just a few. All of these names were unfamiliar to the LD students with whom we were working. Consequently, those names would be very difficult to associate with the appropriate accomplishments. For instance, how could a student best remember that Bryan was a pacifist, rather than, for example, George M. Conan, who was the famous American songwriter who composed the song "Over There"? These names and accomplishments were therefore "reconstructed" via the transformational mnemonic keyword technique. For example, "Bryan" was transformed into the acoustically similar, but easily pictured keyword "lion," and then depicted in an interactive illustration as a lion who was saying, "please no fighting" to two other animals. Students were instructed to think of the keywords for words like "Bryan" and think back to the interactive illustrations to help them retrieve the critical information—in this case, that Bryan was the Secretary of State who was a pacifist. On the other hand, students were taught the keyword "cone" (as in ice cream cone) for George M. Conan. They were shown an interactive illustration of children with ice cream cones being asked where they got those cones and replying in singing voices, while pointing "Over There, Over There," to help recall that George M. Conan was the composer of the song "Over There." Again, students were reminded how to retrieve the appropriate response when asked the stimulus "Conan."

It is important to note that proper names may or may not be unfamiliar to specific learners. Had we encountered names that were familiar to the students (e.g., Madonna), it would not have been nec-

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essary to transform them into more familiar keywords. We would have been able to simply depict such a familiar person in an interactive illustration with the to-be-remembered response, as in the mimetic example above. As can be seen, we developed rules for the circumstances under which reconstructive elaborations were used.

RULES FOR USING RECONSTRUCTIVE ELABORATIONS

Stimulus-response information that needs to be recalled will be recalled better if a reconstructive elaboration is made. The stimulus and response information should be made familiar and concrete and shown in an interacting picture or image.

Rule A

If the stimulus-response information is already concrete and meaningful to the learners, simply provide an interactive elaboration between the stimulus and the response. Use of picture or mental images is particularly helpful.

Rule B

If the information is familiar but abstract, reconstruct that stimulus into something more concrete and more meaningful for the learners, and then provide an interactive illustration or image for the learners with the reconstructed stimulus and the response. This may be accomplished by concretizing abstract concepts like "justice" or "liberty" with symbolic representations, such as scales, or Uncle Sam as a symbolic representation of United States policy.

Rule C

If the information is unfamiliar, such as with unfamiliar names, places, and vocabulary words, reconstruct the item into something more concrete and familiar for the learner by means of the keyword method, and then depict that more concrete and familiar response in an interactive elaborative picture or image.

EVALUATION COMPONENT

In our most recent experiment (Scruggs & Mastropieri, 1988), 28 learning disabled students were instructed via either our reconstructive elaborations or control condition materials. The LD students in this study were eighth, ninth, and tenth graders, attending mainstream content-area classes as well as LD resource programs in a midwestern, urban school district. These students were performing in the low average range as measured by individual intelligence tests and were performing an average of 4 years below grade level in reading and math.

These students were all taught the information on World War I that had been adapted from an eighth-grade level U.S. history textbook. After instruction, all students were given an immediate production test on the information on World War I, and a 3- to 4-day delayed identification test. Students who were instructed using the reconstructive elaborations recalled approximately twice as much information on World War I than their control counterparts on both immediate and delayed recall tests. We are currently continuing this line of research and attempting to replicate the study with LD students in the elementary grades, using science as well as state and U.S. history content. Results of these investigations provide a model for the comprehensive integration of relevant elaborative techniques to dramatically improve the learning and memory of content-area information for LD students.

At present, we have evaluated the feasibility of the model as applied to actual content-area learning. Our current work has demonstrated some initial success with researcher-developed materials (Scruggs & Mastropieri, 1988) and with teacher-developed materials (Mastropieri, Emerick, & Scruggs, in press). Future research efforts should address the application of these strategies in a variety of additional content areas. For example, some anecdotal evidence has recently appeared that mnemonic instruction can be very helpful in the acquisition of critical academic skills such as phonics and spelling. Some additional topics for inquiry are materials adaptation for highly abstract and conceptual content domains, such as advanced mathematics and physical science. Finally, additional information could be gathered regarding the extent to which LD students can participate in developing and implementing such strategies independently or with minimal teacher assistance. At present, however, it appears that mnemonic instruction incorporating the principles of reconstructive elaborations has great potential for improving the chances of school success of LD students.

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Appendix J

Mastropieri, M.A., & Scruggs, T.E. (1990). Memory and learning disabilities. Learning Disability Quarterly, 13, 234-235.

MEMORY AND LEARNING DISABILITIES

Margo A. Mastropieri and Thomas E. Scruggs

Prior to 1970, few researchers or clinicians interested in the problems of learning disabled (LD) individuals systematically examined the potential role of memory difficulties related to school learning (see Cooney & Swanson, 1987, for an extensive review). During the 1970s, however, an increased focus on memory became apparent in the research literature, as evidenced by Torgesen and Dice (1980), who reported that 18% of articles in learning disability journals published between 1976 and 1979 made some reference to memory disabilities (Pressley, Heisel, McCormick, & Nakamura, 1982). Although some of this research was valuable (Torgesen & Kail, 1980), many of these endeavors have not contributed to a lasting body of research evidence.

During the 1980s, interest in the role of memory in learning disabilities increased substantially, with contributions by researchers representing a wide range of academic disciplines. In 1987, Lee Swanson edited an entire scholarly volume devoted to memory and learning disabilities, which serves as testimony to the amount of recently reported research evidence that surrounds theoretical and practical aspects of memory and learning disabilities. Further, researchers have begun to uncover problems that have been apparent to many special educators for years: that many of the difficulties exhibited by LD students are a function of deficits in memory processes. These processes are not just important for experimental list learning, but play a key role in reading, writing, spelling, mathematics, language, study and/or organizational skills, science, social studies, and virtually any other academic area. These findings led Cooney and Swanson (1987) to conclude, "During the past few years, the study of learning disabled children's memory has become a cornerstone of research in the field" (p. 2).

Lee Swanson has asked us, at the start of a new decade, to compile an issue of the *Learning Disability Quarterly* of important new research on memory and learning disabilities. We have attempted to bring together new research, representing several different, but interrelated perspectives. Taken together, we feel these articles offer the field new and important information regarding memory processes in LD students and their implications for instruction. In this issue, we have provided articles from basic to applied research areas.

In the first article, Torgesen, Wagner, Simmons, and Laughon give a perspective on LD students who exhibit problems with phonological coding. These authors provide evidence that this subgroup of LD students exhibit primary deficits on naming digits and letters in series, presenting theoretical support for their argument. They conclude that this may be a fruitful area for future inquiry into assessment of children with learning disabilities.

The next article was contributed by Cesare Cornoldi, a Professor of Psychology from the University of Padua, Italy. He describes his recent work with Italian LD children who have learned basic decoding skills, but exhibit persistent deficits in text comprehension. He draws parallels between control processes demonstrated in reading comprehension tasks and experimental memory tasks, particularly with respect to the "time allocation strategy," whereby students allocate study time differentially depending on their judgment of relative information difficulty. Cornoldi discusses instructional implications for reading comprehension.

McDaniel, Einstein, and Waddill describe text-processing of item-specific and relational information in descriptive and narrative texts. They argue that different types of text invite specific types of processing and that text type and student ability level should be considered when designing optimal materials for

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these populations. Their "material-appropriate framework" sheds valuable light on strategies that are appropriate for LD students when dealing with different types of text.

In the final article, we offer some of our own thoughts regarding mnemonic (memory-enhancing) strategy instruction, an instructional application that is of direct relevance to more theoretical perspectives on memory. Although, in recent years, a number of research reports have documented the efficacy of these unusual techniques, we chose to take this opportunity to describe mnemonic instruction in more general terms. Following an overview of the use of mnemonics with LD students, we present the results of these experimental applications.

We would like to thank the authors of the articles in this issue for an excellent set of papers on memory and learning disabilities. We would also like to extend our thanks to Lee Swanson, who offered us the opportunity to guest edit this issue of the *Learning Disability Quarterly*. It is only his own modesty that prevented him from contributing an article of his own to this issue—we hope that the reader interested in pursuing the area of memory and LD further will examine his chapter (Swanson, 1987b) in his edited 1987 volume on the subject, or Swanson (in press) for his more recent thoughts on applications of this area to practice.

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Appendix K

Mastropieri, M.A., Scruggs, T.E., Whittaker, M.E.S., & Bakken, J.P. (1990). Translating research to practice: Results of classroom applications of mnemonic strategy instruction. West Lafayette, IN: Purdue University, Department of Educational Studies.

Translating Research to Practice: Results of Classroom Applications of Mnemonic Strategy Instruction

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Running Head: CLASSROOM APPLICATIONS

Abstract

This paper reports the results of two classroom applications of mnemonic instruction with mildly mentally handicapped students. These application projects were developed based upon previous research findings. In both applications regularly assigned curriculum was adapted to include the use of mnemonic strategies. In the first application, the strategies were supplied by the teacher to facilitate the learning of social studies content. In the second application, students first used teacher-made strategies and later assisted the teacher in generating "class" mnemonic strategies for learning science content. Results of both applications suggested that students successfully learned the content presented using the mnemonic strategies and reported enjoying instruction when the strategies were used. Findings are discussed in relation to future applications for teachers.

Translating Research To Practice: Results of Classroom Applications of Mnemonic Strategy Instruction

Recent research has suggested that students with learning disabilities are more successful at learning science and social studies content when teachers have implemented mnemonic (memory-enhancing) strategies during instruction (see Mastropieri & Scruggs, 1989a and Scruggs & Mastropieri, 1990a; 1990b for recent reviews). The initial investigations relied upon teaching small units of content under very structured conditions (e.g., Scruggs, Mastropieri, Levin, & Gaffney, 1985). The content instructed included English and foreign language vocabulary tasks (e.g., Mastropieri, Scruggs, Levin, Gaffney, and McLoone, 1985), and learning attributes of minerals and dinosaurs (e.g., Veit, Scruggs, & Mastropieri, 1986). Students' performance was compared with a variety of control conditions, such as direct instruction, rehearsal, visual spatial displays, and free study. Results of all of those studies revealed substantial statistical advantages for the mnemonic strategy conditions.

Later investigations involved the development of mnemonic strategies based upon the adaptation of larger content areas from regularly assigned textbooks and resource materials (e.g., Mastropieri & Scruggs, 1988). In the development phase of these investigations, entire content domains, including all instructional materials, textbooks, workbooks, and related resource guides were examined and analyzed to identify important information. Then, in consultation with teachers, the information that was considered to be the most important for students to master was selected. Based upon that core of identified content, the "reconstructive elaborations" model (see Scruggs & Mastropieri, 1989) was employed to develop appropriate strategies. Specifically, that model incorporates principles from cognitive psychology based upon elaboration learning research (e.g., see Glover & Bruning, 1987), and uses the learner's prior knowledge and appropriate levels of meaningfulness, familiarity, and concreteness.

For example, to develop a strategy appropriate for students with learning disabilities to learn that the earth's mantle is made of solid rock, first, it was determined that mantle was an unfamiliar term for students. The term mantle was then reconstructed to an acoustically similar, but very familiar and concrete (to all of the students) term, man. Next, the reconstructed term man had to be elaborated (or interacted or connected) with the to-be-remembered response information, made of solid rock. In this case, an illustration of a rock man was drawn (a man made out of solid rock-- see Figure 1). Accompanying teacher presentation scripts and student practice activities were then designed to include specific practice using and retrieving the strategy. For example, to retrieve the information associated with the earth's mantle, students were told to first think of the keyword (in this case, "man"), then, to think back to the picture with the man in it and think about what was happening in the picture. In this example, they should think of the "rock" man before retrieving the appropriate response, "earth's mantle is made of solid rock". All mnemonic strategies employed in that research were developed using similar principles.

Insert Figure 1 about here

These research implementation studies resulted in high performance gains on immediate tests as well as on delayed measures administered up to eight weeks after instruction, for students with learning disabilities. Additionally, students consistently reported enjoying instruction more when their teachers used these strategies. All involved teachers reported liking the materials and thought that their students participated more in class discussions and generally appeared more motivated to learn when they used the mnemonic strategies as compared with their traditional procedures.

Although these findings were positive and provided instructional implications for students with learning disabilities, it was unknown the extent to which similar procedures and strategies could be successfully applied with students classified as having mild mental handicaps (MiMh). Previous investigations with MiMh populations had been limited to short term laboratory-type research, such as that of Scruggs, Mastropieri, and Levin (1985), who successfully implemented this mnemonic strategy with students with mental retardation using a list of vocabulary words. However, it was unknown whether students with MiMh could meet the information processing and attentional demands necessary for learning using these mnemonic strategies over extended time periods. Further, although students with learning disabilities had reported enjoying this type of instruction, would students with MiMh report similar feelings, even though the strategy placed high cognitive demands on them during learning? Finally, would it be possible to translate the previous research findings into applied projects in classrooms? With these questions in mind, the present application projects were designed.

First Application Project

Classroom Problem, Purpose and Design of Application Project

The first application project was designed to help middle-school students with MiMh learn social studies content. The teacher had reported that all students were required to learn the names of the states and capitals of the U.S. She had reported trying to teach the students that content using a variety of methods, such as pictures of the states, textbook related materials, maps and outlines of each state with its respective capital highlighted, and computer program practice activities. She reported that after instruction of as few as four or five states and capitals a week, students learned virtually no information, and that she as well as the students were frustrated with the task. Therefore, it was decided to try to teach that content using mnemonic strategies over a four to five week period.

Description of Students and Classroom

Eight students (five girls and three boys) who were all classified as mildly mentally handicapped (MiMh) according to state and federal criteria, were members of a daily, fifty minute class period of social studies instruction. The junior high school they attended was located in a lower socio-economic status area in a large midwestern city. Students ranged in age from 13 years 2 months to 14 years 6 months with a mean age of 13 years 11 months (SD = 4.6 months), and had been enrolled in special education classes for an average of 5.1 years. Six of the eight students received special education services for a minimum of four hours per day, during which time they received instruction in all of the major content areas. The average Wechsler Intelligence Scale for Children-Revised (WISC-R) IQ was 68.88 (SD = 12.1) (range 43 to 80). Mean achievement standard scores, as measured by the Wide Range Achievement Test - Revised, or the Woodcock-Johnson Psychoeducational Battery were: math 71.7 (SD = 14.3), spelling 75.5 (SD = 16.3), language arts 79.0 (SD = 4.6) and reading 66.5 (SD 7.5).

Materials

Materials were developed to teach the states and capitals using a complex mnemonic strategy. Since it was determined that both state and capital names were unfamiliar to these students, keywords were developed for both names. Then, interactive illustration depicting both keywords were drawn. Final materials consisted of overhead transparencies, practice activity packets and sequencing cards that all contained aspects of the mnemonic strategies as described below.

Overhead transparencies contained the strategy to teach the names for states and capitals. Each 8 1/2 by 11 inch transparency had the state name and its keyword in the upper left hand corner, the capital name and its keyword in the right hand corner, and in the center a mnemonic illustration showing the keywords for the state and capital name interacting. For example, to teach that Albany is the capital of New York, New York and its keyword new pork were in the upper left hand corner of the transparency, Albany and all baloney (keyword for Albany) were in the upper right hand corner, and a picture of a person asking a butcher "is this new pork" (keyword for New York), and the butcher replying, "no it's all baloney" (keyword for Albany), appeared in the center of the transparency (see Figure 2).

Insert Figure 2 about here

The practice activity packets contained worksheets designed to reinforce the information from the transparencies. Some worksheets included "fill in the blank" activities where students were required to produce keywords and answer questions about the pictures. For example, students were asked to write the keyword for New York or asked to write the capital that all baloney represented. Additionally, unlabeled pictures that were reduced versions from the transparencies were included and students were required to write the appropriate information next to each picture. Some worksheets contained matching-type activities that required students to match the respective states and capitals from a listing. Word search activity sheets that contained the names of states and capitals were also included. Finally, blank paper was included for students to practice drawing their own mnemonic illustrations.

A series of sequencing cards were also developed. These were used to facilitate the learning of the sequential steps necessary to execute and retrieve the complex strategy. For example, the card sequence for "What is the capital of New York" included: (a) a card with the question "What is the capital of New York?"; (b) a card with the statement "Think of the keyword 'new pork'."; (c) a card with target picture on it (see Figure 2); (d) a card with the statement "Think of the keywords all baloney."; and (e) a card with the statement "Albany is the capital of New York."

Procedure

Since students answered virtually nothing correct on a pretest of the states and capitals, a sample of 20 states and capitals were selected for use in this classroom application project (see Table 1 for a complete listing). Students were told they were going to be taught to use a new method for learning the names of the states and their capitals during social studies class. They were told to try hard because they would be given tests to determine how many states and capitals they learned. New states and capitals were introduced slowly to allow students the opportunity to master content prior to introducing new, and potentially confusing content.

Insert Table 1 about here

The basic model of teacher effectiveness as described by Mastropieri and Scruggs (1987) was implemented throughout all phases of instruction. Each class began with a daily review of previously covered content, then the teacher presented the new information and provided opportunities for students to participate actively throughout the presentation. This was followed by a guided practice activity that was typically initiated as a group activity with the teacher presenting verbal cues and calling on students for individual responses, but ended as an independent practice activity, with the teacher circulating around the room providing assistance wherever necessary.

Finally, the practice activities were evaluated during a group activity and students were provided performance and strategy-related feedback.

When the teacher introduced new states and capitals, initial time was spent familiarizing students with those names and their respective keywords. Instructions were presented to accompany the interactive mnemonic illustration. The teacher said, for example:

> "To help you remember that Albany is the capital of New York, remember the keywords, all baloney for Albany, and new pork for New York. Then think of this picture of a person asking a butcher 'Is this new pork?' and the butcher replying, 'No, it's all baloney! What is the important information in this picture [elicits responses]? If I ask you the capital of New York, first think of its keyword... [elicits responses] new pork. Then think back to the picture with the new pork in it. Think about what was happening in that picture [elicits responses]. Someone was asking 'is new pork?' and the butcher was replying, 'No it's all baloney!' Then, think of the other important keyword in that picture.. [elicits responses] all baloney. Finally, remember that all baloney stands for... [elicits responses] Albany."

Students were required to answer questions orally (both individually and in groups), then, guided practice activities using worksheets from the packets were completed and reviewed.

This activity was followed by the introduction of the "thinking sequence cards" described previously. These cards were presented in a mixed-up order and students were required to sequence them appropriately. Initially this was completed as a group activity followed by small group and individual practice. For example, cards were randomly distributed to students and the teacher would ask for volunteers to place the correct sequence of cards on the chalkboard tray.

This instructional format was followed for four weeks during which time 20 states and their respective capitals had been introduced and practiced. A three day cumulative review took place on the first days of the fifth week. During this review the teacher used similar instructional procedures but included all of the content covered. The next day students were administered a cumulative recall test.

Results and Discussion

A cumulative multiple choice test (each question was followed by four possible answer choices) was administered to students individually. All items contained distractors that were taught during the four weeks. Sample items included:

What is the capital of Wisconsin?

A. Montgomery B. Madison C. Montpelier D. Denver

What is the capital of Minnesota?

A. Sacramento B. Salem C. St. Paul D. Pierre

Following the test, students were administered a strategy questionnaire. They were asked, for example, to describe how they remembered each item (e.g., How did you remember the capital of New York?) Students' verbatim responses were recorded.

Across all of the 20 multiple choice items, students recalled an average of 94 percent correct. All but two students obtained perfect scores (one student missed four responses, while another student missed five). Students' strategy data indicated that they were successfully able to report the strategy information for the majority of the states and their capitals. Four of the students who received perfect recall scores also reported all of the associated strategies correctly. The other student with a perfect recall score was unable to retrieve two of the strategies, even though she correctly recalled the responses. Of the two students who missed four and five items each, respectively, one correctly retrieved 13 strategies, and the other 12. All students reported enjoying the strategy instruction, and the teacher reported being amazed that they learned as much information as they did.

This application project demonstrated that a very complex mnemonic strategy could be taught to individuals classified as mildly mentally handicapped. Additionally, this project provided evidence that these MIMh students did not confuse information learned mnemonically over a five week instructional period. Finally, this project applied the procedures from findings provided by previous research conducted with learning disabled students to actual classroom practice with MiMh students. Next, of interest, was the extent to which MiMh students would become involved in the generation of their own mnemonic strategies when guided and prompted by their teacher. It was also of interest to determine whether similar applications could be successfully implemented in another content area. The second application project was designed to provide insight into those questions.

Second Application Project

Classroom Problem, Purpose and Design of Application Project

The second application project was designed to facilitate the learning of science content for high school aged students who had been classified as MiMh. The teacher had reported that all students were required to learn various body parts, including the parts of the eye and the ear as part of their regularly assigned science curriculum. She reported trying to teach students that content using a variety of methods, such as, pictures of the eye and ear, and practice activities designed to promote learning, but students experienced difficulty learning the information with these methods.

It was decided to implement instruction in learning the parts of the eye and ear using mnemonic strategies. During the first nine sessions the teacher presented the mnemonic strategies to students that she had developed, while during the following sessions students were prompted to generate "class" mnemonic strategies.

Description of Students and Classroom

Nine students (five boys and four girls) who were all classified as mildly mentally handicapped (MiMh) according to state and federal criteria were members of a daily class period of science instruction. The students were all enrolled in a Prevocational Education Program for mildly mentally handicapped students, which was part of a public school in a rural midwestern community. The students ranged in age from 15 to 18 years and were classified as either high school freshmen or sophomores. All of the students received special education services for the majority of the school day, during which time they received instruction in all of the major content areas and prevocational areas. The average WISC-R IQ score was 72 (range 64 to 78). Achievement scores, as measured by the Wide Range Achievement Test - Revised, for reading, math, and spelling ranged from the beginning third grade level to the beginning fifth grade level, with an average of the beginning fourth grade level.

Materials

Materials were developed to accompany the regularly assigned science textbook. Seven parts of the eye and nine parts of the ear, as well as their corresponding definitions were identified as the target content for students to learn using the mnemonic materials. Materials consisted of overhead transparencies, the textbook, and class discussion materials. One overhead transparency was developed to teach each part of the eye and ear.

Each 4 by 11 inch transparency contained: the name of the part of the eye or ear, the keyword for that part, and an illustration depicting the keyword interacting with the part of the eye or ear. For example, to teach that the "pupil" was "the dark hole in the iris that let light into the eye," the keyword "pill" for pupil was taught, and students were shown an illustration of a "pill" in the place of a pupil embedded within a line drawing of an eye, and the "pill" looked like light was going through it.

Procedure

Two phases of instruction were implemented. The first phase was the teacher presentation phase, and the second was the prompted generalization phase. The procedures common to both phases are presented first, followed by phase specific procedures.

Both phases. Students were told they were going to be taught to use a new method for learning the parts of the eye and the ear during science class. They were told to try hard because they would be given tests to determine how much information they learned. The eye parts were presented first, followed by the ear parts. As in the first application project, the general model of teacher effectiveness as described by Mastropieri and Scruggs (1987) was followed throughout the project. After the teacher began the class with a daily review, the new information was presented, followed by guided and independent practice. The guided practice activity was always a group activity during which time the teacher presented numerous opportunities for practicing the newly introduced information. Specific performance and strategy feedback were provided throughout instruction.

Teacher presentation phase. During this phase of instruction, students were introduced to the principles of the mnemonic strategy. They were taken step by step through the keyword strategy for learning the definition or function of each body part. The teacher began by presenting to students the new eye part and its keyword. She explained why the keyword was selected, emphasizing that the acoustical similarity between the keyword and the part of the eye were critical. Then, the definition of that part of the eye was paired with the word and its keyword. Once students appeared to know the new eye part and its keyword, the transparency was presented which contained that information as well as the interactive illustration. Explanations regarding how the interactive illustration would help facilitate retrieval of the information were presented. The teacher described how the keyword and the eye part's definition were interacting in the picture. Students were taught when asked the definition to first think of the keyword, then think of the picture with that keyword in it and what was happening in that picture. Finally, they were taught to retrieve the appropriate response. The teacher emphasized that the strategy would help students learn and remember the information.

After two sessions, the teacher did not need to spend as much time describing how the strategy worked. After that time students appeared to catch on. A new body part and definition were introduced daily and all parts covered to date were included in daily review sessions. The day prior to a test, review of all content covered was completed without the use of the transparencies. If students were unable to retrieve the correct response, the teacher placed the appropriate transparency on the overhead projector and reviewed all the steps for successful execution of the strategy.

Prompted generalization phase. After nine sessions of instruction with the teacher presentation of the entire mnemonic strategy, students were asked to generate keywords and interactive illustrations as a class with the teacher. The teacher began these sessions by stating that previously she had prepared keywords and illustrations for the class and that those strategies had helped everyone do well on the test. She said that she did not have any more keywords and pictures for the remaining ear parts, but that she felt that they could, as a class, come up with their own strategies. She led the class discussion by presenting one of the ear parts and its definition. She said, for example, "Today's ear part is the cochlea. What might be a good keyword for us to use to remember cochlea? What else do you know that sounds like cochlea?" Students volunteered responses and the teacher encouraged all students to participate in the brainstorming activity. She repeated the criteria for a good keyword as "something that sounds like the word, and is already familiar to us." After several suggestions were made, the teacher used her judgement and selected what she considered to be the best keyword for the class. For the cochlea example, "rock" sounded most similar to the first syllable "coch" and all of her students were familiar with "rock", so that became the "class keyword." Then, the associated definition of cochlea was presented to the class as "a small snail-shaped tube in the inner ear." Students were asked to think of a good interactive illustration that contained their new keyword (rock) and the to-be-remembered definition (small snail-shaped tube in the inner ear). Ideas were solicited from all students and the teacher prompted students to generate ideas reminding students that the keyword and its definition must be doing something together. After all ideas were solicited, the teacher again selected what she considered to be the optimal one, based upon all the students' prior knowledge levels. In the cochlea example, a snail sitting on a rock, where the snail's shell was shaped exactly like the cochlea was ultimately selected. The next day the teacher brought in an overhead transparency of the class generated strategy from the previous day, and reviewed it extensively with all students. The review procedures paralleled those described in the teacher presentation phase. New ear parts were introduced using procedures parallel to the cochlea example.

Results and Discussion

Four tests were administered throughout this applied project. One test followed the eye unit, one test followed the ear unit, and two cumulative tests (over the eye and ear units) were administered at delay intervals up to two weeks after the ear unit. All tests consisted of a matching format that listed items at the top of the page, with definitions/functions listed in a random order at the bottom of the page. Results on the recall tests were as follows: On the eye test, students recalled an average of 77% (SD = 19.4) of the information; on the ear test, students recalled an average of 62% (SD = 22) of the information, and on each of the cumulative tests students recalled 78% (SD = 21.1 and 23.7, respectively) of the information. On the cumulative tests, however, only three of the original items from the prompted generalization phase were used. All of the other items were from the teacher presentation phase. However, the mean score for student recall on the prompted generalization items was virtually identical to the overall score (M = 78, SD = 37.2). Six of the students recalled all three of those items, while one student recalled two, one student recalled one, and a single student recalled none of those items.

The performance on the prompted generalization unit was lower than the performance on the teacher presented unit. Interestingly, however, the recall level on the two cumulative tests remained stable. One student performed poorly on all tests, with her scores ranging from 30% to 40%, and those performance levels were representative of her performance under traditional instructional procedures throughout the year. The students reported liking the use of these mnemonic strategies, not only when the teacher supplied the entire strategy, but also when they were prompted by the teacher to generate a class strategy. The teacher also reported enjoying instruction under mnemonic instructional procedures, however, she reported that additional preparation time was required on her part. Additionally, she reported that at times she experienced difficulty drawing the illustrations, and that she needed more instructional time with the students during the prompted generalization phase.

General Discussion

Taken together, the results of these two classroom application projects replicate and extend what is known about the circumstances under which mnemonic strategies can be successfully implemented within classroom environments by teachers. In both application projects, the regularly assigned curricular materials were adapted to include the use of mnemonic strategies, and then these strategies were integrated within the regular instructional procedures by the assigned teacher. Additionally, in these projects, students who were classified as mildly mentally handicapped were successful at learning science and social studies content when their teachers used this strategy instruction. Students and teachers in both classes also reported enjoying instruction when mnemonic strategies were implemented.

The information processing demands appeared to be well within the limits of these students, as evidenced by their learning the assigned content, and by the strategy reports in the states and capitals project. There did not appear to be any confusion among all of the various keywords used to teach the states and the capitals, even though this is a very complex strategy. If students had been unable to describe the strategies accurately, then it might appear that the task was too difficult for this population.

Perhaps even more interesting, is the evidence that adolescents with mild mental handicaps were capable of generating a "class" strategy with prompting and guidance from the teacher. After several lessons during which the teacher presented the entire strategy, students were actively encouraged and prompted to assist in developing novel strategies for the newly presented content. This replicates findings from the Scruggs and Mastropieri (in press) study conducted with learning disabled students. The present procedures differed somewhat from the Scruggs and Mastropieri study in that the learning disabled students drew their own mnemonic illustrations after generating a group strategy. It is noteworthy, however, that student performance levels were slightly lower under the prompted generalization procedures, compared to the teacher developed procedures, and that instruction proceeded at a somewhat slower pace. Again these finding parallel those described by Scruggs and Mastropieri (in press).

On a somewhat disappointing note, however, the present findings also indicate that the amount of instructional time needed to teach MiMh students to use these mnemonic strategies may be much more extensive than previously anticipated. In the first application project these students needed extensive practice with all aspects of the states and capitals strategy before they could master all necessary steps. For example, in a related project, Mastropieri, Scruggs, Bakken, and Brigham (1990) reported teaching approximately twice as much content in a similar amount of time to junior high school learning disabled students.

Optimistically, however, it appears that procedures reported in the research literature can be translated to applied projects in the classroom. In the present application projects, modifications of the instructional procedures from reported research were made and modifications continued to be made by classroom teachers during the application projects. Apparently, at least in the present examples, when teachers carefully monitor not only their own instructional procedures, but also student performance, adjustments can be made to facilitate student progress. Translation of research to practice projects are important if what is deemed necessary is advancing the progress of special needs students.

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Table 1

States and Capitals and Mnemonic Strategies Implemented

State (Keyword)	Capital (Keyword)	Strategy
Alabama (band)	Montgomery (monkey)	A band made up of monkeys.
Arkansas (ark)	Little Rock (little rock)	An ark stuck on a little rock.
Colorado (coloring)	Denver (den)	Children coloring in a coloring den.
California (calf's horn)	Sacramento (sack of mint)	A calf's horn stuck in a sack of mint.
Delaware (devil)	Dover (dove)	A devil with a dove on it.
Florida (flower)	Tallahassee (television)	A television with a flower on it.
Indiana (Indian)	Indianapolis (Indy 500)	An Indian driving in the Indy 500 car race.
Louisiana (Louise & Anna)	Baton Rouge (baton & rouge)	Louise and Anna twirling batons and wearing rouge.
Michigan (pitch again)	Lansing (lamb)	A lamb telling the pitcher to pitch again during a baseball game.
Minnesota (mini soda)	St.Paul (St. Paul)	St.Paul ordering a mini soda.
North Carolina (carolers)	Raleigh (trolley)	Carolers singing while heading north on a trolley.
Nevada (new ladder)	Carson City (car city)	A person climbing the new ladder to get up to car city.
New Jersey (jersey)	Trenton (tent)	A jersey hanging on a tent.

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New Mexico (Mexico)	Sante Fe (Santa Claus)	Santa Claus going to Mexico.
New York (new pork)	Albany (all baloney)	A person asking a butcher 'is this new pork,' and the butcher replying, 'no, it's all baloney.'
Oregon (ore)	Salem (sailboat)	A sailboat carrying ore.
Pennsylvania (pen)	Harrisburg (hairy)	A hairy pen.
South Dakota (southern coat)	Pierre (pier)	A man wearing a southern coat standing on a pier.
Wisconsin (whisk broom)	Madison (maid)	A maid using a whisk broom.
Vermont (worm)	Montpelier (mountain pliers)	Mountain pliers pulling a worm out of a mountain.

Figure Captions

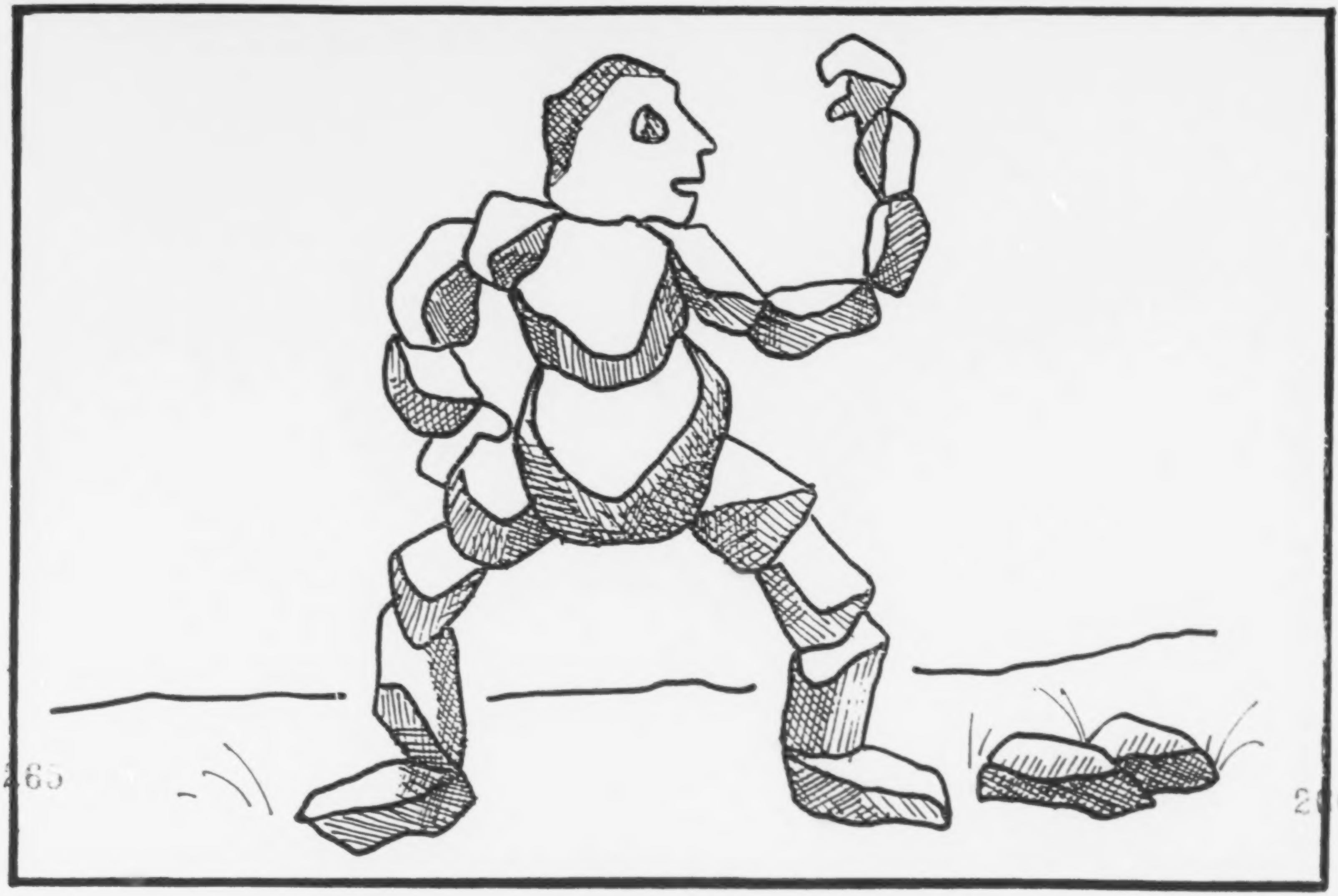
Figure 1. Mnemonic illustration of the earth's mantle made of solid rock.

Figure 2. Mnemonic illustration for teaching the capital of New York.

MANTLE

(Man)

made of solid rock



New York
(new pork)

Albany
("All baloney")

IS THIS NEW PORK?
IT'S ALL BALONEY!
BUTCHER

Appendix L

Mastropieri, M.A., Scruggs, T.E., & Bakken, J., & Brigham, F. (1990). *A complex mnemonic strategy for teaching states and their capitals: Comparing forward and backward associations*. West Lafayette, IN: Purdue University, Department of Educational Studies.

A Complex Mnemonic Strategy for Teaching States and Their Capitals: Comparing Forward and Backward Associations

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Running head: STATES AND CAPITALS

Abstract

Learning disabled students from two self-contained classrooms and one resource program in an inner-city school were taught U.S. states and their capitals in a counterbalanced design across classrooms over a five-week period. Students were taught, in alternating weeks, by either a complex mnemonic strategy or a more traditional procedure. Students scored statistically (and substantially) higher on items taught mnemonically than on items taught traditionally on a 5-week cumulative recall test. The mnemonic advantage was maintained whether students were required to provide either forward (capital) or backward (state) information, although students scored significantly higher in recall of states, regardless of condition. For mnemonically instructed items, significant correlations were found between performance and reported strategy usage. In addition, students and teachers greatly preferred mnemonic instructional procedures. Little or no evidence was found of spontaneous transfer of the mnemonic strategy across instructional conditions. Implications for practice are provided.

A Complex Mnemonic Strategy for Teaching States and Their Capitals: Comparing Forward and Backward Associations

In recent years, the ability of learning disabled (LD) students to remember school-relevant information has been dramatically enhanced with mnemonic instructional techniques (for reviews, see Mastropieri & Scruggs, 1989a; Scruggs & Mastropieri, 1990). Mnemonic instruction involves reconstructing unfamiliar or abstract information into more meaningful and concrete forms, and effectively integrating stimulus (question) and response (answer) information. Such reconstructions afford the opportunity for more effective encoding and retrieval. Given documented deficits of LD students in the area of semantic memory (e.g., Baker, Ceci, & Hermann, 1987), mnemonic strategies hold particular promise for ameliorating such difficulties.

One particularly useful mnemonic technique is the keyword method (Atkinson, 1975). In this technique, unfamiliar words are reconstructed into familiar, acoustically-similar keywords as proxies for target words, and elaborated in a picture with response information. For example, in learning that the Italian word fonda means "bag", learners are first shown (or asked to generate) a keyword for fonda. In this case, "phone" is a good keyword for fonda, because it sounds like fonda and is easily pictured. Next, a picture or image is constructed of the keyword and corresponding response interacting in a picture, in this case, a picture of a phone in a bag. When asked the definition

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of fonda, then, learners think of the keyword, phone, think of the picture with the phone in it, remember the phone was in a bag, and provide the correct response, bag. Such strategies have been shown to be highly effective in increasing vocabulary learning in LD students (Mastropieri, Scruggs, & Fulk, 1990; McLoone, Scruggs, Mastropieri, & Zucker, 1986).

In addition to vocabulary learning, keyword mnemonics have been highly successful in promoting school learning in such content areas as science (e.g., Mastropieri, Emerick, & Scruggs, 1988; Scruggs & Mastropieri, in press a) and social studies (Mastropieri & Scruggs, 1988, 1989b; Scruggs & Mastropieri, 1989). Mnemonic instruction with LD students has also been shown to have a facilitative effect on delayed recall, comprehension, and affective measures (Scruggs & Mastropieri, in press c).

In spite of the documented successes of mnemonic instruction with LD students, however, several questions remain unanswered. One question which has been frequently raised is the issue of forward vs. backward recall of mnemonically-instructed information. For example, will students who have been taught mnemonically that fonda means "bag" be able to respond "fonda" when asked, "What is the Italian word for bag?" Logical analysis suggests that, while a bag is clearly pictured in the mnemonic illustration, it is unclear whether students retrieving the mnemonic picture could readily answer fonda, given a picture of a phone. Such backward retrieval may present difficulties, since

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fonda is the unfamiliar term, and may not be easily retrievable given only the acoustically similar keyword. Forward vs. backward retrieval is an important question for educational applications, since good teaching requires that students be able to provide relevant information when asked in a variety of contexts. Previous mnemonic instructional research has not directly addressed this question, which provides the basis for the present investigation.

Another question of importance is the level of complexity of mnemonic strategies which can be useful to LD students. When stimuli and responses are unfamiliar or abstract to learners, both components must be reconstructed to keywords. This would necessitate the learning of two keywords for one association, in addition to the retrieval of a response from one keyword, given the other keyword. For example, to learn that the capital of Wisconsin is Madison, keywords must be constructed for Wisconsin as well as Madison. In this instance, whisk broom is a good keyword for Wisconsin, and maid is a good keyword for Madison. An interactive mnemonic illustration could depict a maid using a whisk broom, as shown in Figure 1. When asked for the capital of Wisconsin, then, learners must first think of the keyword for Wisconsin, whisk broom, think of the picture of the whisk broom, think of what else was in the picture, retrieve the maid as a keyword, remember the capital name represented by maid, and provide the correct response, Madison. As can be seen, this is a substantially more complex application of mnemonic instruction than the fonda example. Prior to this investigation, it was unknown whether LD students could meet the information processing demands of such a strategy.

Insert Figure 1 about here.

The learning of states and capitals is not only an important part of the regular education curriculum, but also provides an ideal opportunity to investigate the learning of forward and backward associations. For example, under mnemonic instruction can students learn to respond with either state or capital names as the occasion requires? The present investigation also was designed to address this question.

In contrast to earlier, laboratory-type investigations (e.g., Mastropieri, 1983), we designed the present investigation to incorporate the conditions of ongoing classroom instruction. Although such research presents challenges, it can also contribute greatly to the external validity of the procedures, and therefore, its relevance to classroom implementations.

Method

Design

The target school was located in an inner-city neighborhood, and characterized by low rates of attendance. We therefore anticipated that attrition problems could potentially interfere with the implementation of the study. In order to address this issue, as well as difficulties with random assignment in ongoing classrooms, we employed a crossover design in which all students received both mnemonic and traditional instruction on alternate weeks, in counterbalanced order. With such a design, subject attrition is less of a problem. Since each subject serves as his or her own control, differential attrition by condition is not possible.

Each of two self-contained LD classrooms (three resource students were included with one classroom) received mnemonic and traditional instruction on different alternating weeks. That is, Classroom A received mnemonic instruction on weeks one, three, and five, and traditional instruction on weeks two and four. Classroom B received mnemonic instruction on weeks two and four, and traditional instruction on weeks one, three, and five. The same states and capitals were taught each week to both conditions.

Subjects

Subjects were 29 learning disabled middle school students from a lower socio-economic status (SES) background, receiving social studies instruction from special education teachers. Of those, three received special education for only one period per day, while 26 received the majority of their instruction from special education teachers. The 20 male and nine female students were enrolled in seventh (N=26) or eighth (N=3) grades, and included 18 Anglo and 11 Black students. Average age of the sample was 14 years, three months (SD = nine months).

All students had been classified learning disabled according to state and federal standards, and had been so classified for an average of 3.9 years (range one to six years). Average full scale IQ for the sample, according to the Wechsler Intelligence Scale for Children - Revised was 86.4 (SD = 6.7). Average Performance Scale was 92.9 (SD = 8.9), and the average Verbal Scale was 82.4 (SD = 7.6). Average scaled score equivalents for reading, spelling, and math, respectively, were 70.1 (SD = 7.6), 66.4 (SD = 10.9), and 75.5 (SD = 11.5), as measured by the Wide Range Achievement Test - Revised, the Peabody Individual Achievement Test, or the Woodcock-Johnson Psychoeducational Battery. All students were characterized by their teachers as having difficulty remembering content area information, specifically, social studies content. A pretest administered prior to the onset of this investigation revealed that students had virtually no prior knowledge of states and their capitals.

Materials

Both conditions. Materials for teaching forty states and their capitals were developed for each condition. Each set of materials contained overhead transparencies of the state and capital information, teacher guidelines/scripts, and student booklets that contained worksheet practice activities. Amount of information presented and practice activities were equated across conditions.

Mnemonic condition. Forty mnemonic illustrations were depicted on separate overhead transparencies. Each illustration contained the name of the state, the name of the capital, and keywords for state and capital names, which were also depicted in an interactive illustration. For example, to teach that *Madison* is the capital of *Wisconsin*, a maid (keyword for Madison) was depicted using a whisk broom (keyword for Wisconsin), as shown in Figure 1.

Some illustrations were more complicated, requiring dialogue to provide the relevant semantic elaboration. For example, to teach that *Albany* is the capital of *New York*, a woman is pictured shopping at a meat counter. She asks, pointing to the meat, "Is this *new pork*?" (keyword for New York), and is told by the butcher, "No, it´s *all baloney*!" (keyword for Albany). Some other example illustrations are listed below:

State (keyword)	*Capital (keyword)*	*Illustration*
Washington (wash-a-ton)	Olympia (Olympics)	People at an Olympic event washing a ton of laundry.
New Hampshire (hamster)	Concord (Concorde)	A hamster flying the Concorde jet.
Florida (flower)	Tallahassee (television)	A flower on television.
Connecticut (convict)	Hartford (heart)	A convict pounding

		rocks into heart shapes.
Kentucky (kennel)	Frankfort (frankfurters)	Dogs eating frankfurters at a kennel.

Complete examples of these strategies are provided in Mastropieri and Scruggs (in press).

In addition, mnemonic condition materials included teacher guides and scripts for delivering instruction, and worksheets for practice activities. Worksheets included reduced versions of the mnemonic illustrations, in which students were required to supply missing labels, and fill-in-the-blank practice activities, which required students to practice retrieving keywords as well as state and capital names.

Traditional condition. Parallel materials were developed for this condition. Transparencies were developed of state outlines with capitals represented by stars in the appropriate location, and state and capital names depicted at the top of the illustration, as shown in Figure 2. In addition, equivalent teacher guides, scripts and student worksheets were included. The worksheets required the students to practice retrieving state and capital information, and provide information for fill-in-the-

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Insert Figure 2 about here.

----

blank activities.

Procedure

Both conditions. Students were taught by one male or one female graduate student who were certified as teachers, in the presence of the regularly assigned special education teacher. A third graduate student monitored fidelity of treatment implementation for both conditions, and videotaped a sample of the instructional sessions in both conditions. Feedback was provided as necessary to maintain treatment fidelity. Regardless of condition, teachers employed the teacher effectiveness variables, which included daily and weekly review; statement of objective; delivery of instruction with appropriate pace, questioning and feedback; guided and independent practice; and formative evaluation (Mastropieri & Scruggs, 1987).

Each instructional period was approximately 50 minutes in length. Each week, eight new states and capitals were introduced (at a rate of about two a day), and any previously learned content was reviewed. After daily review and presentation of new information, students were provided with guided and independent practice using a variety of practice activities. These included the use of worksheets and student booklets, as well as game-type practice activities, such as modified versions of "Jeopardy." One day of instruction per week was lost during the last two weeks of the intervention, because of school scheduling constraints. However, number of days of instruction was consistent across conditions. On the last day of each week of instruction, a test of information covered to date was administered. At the end of the fifth week of instruction, a test of all state and capital information was given.

Mnemonic condition. When mnemonic instruction was administered, the teacher presented the mnemonic illustration on the overhead projector, and orally practiced the keywords, their interaction, and retrieval strategies. Relevant feedback and practice activities were then provided, and students were prompted to use relevant mnemonic strategies to facilitate retrieval. A detailed example of dialogue from mnemonic instruction is given in Figure 3.

Insert Figure 3 about here.

Traditional condition. Instructional conditions paralleled exactly the mnemonic condition, with the exception that traditional state-and-capital overheads were presented, and instruction and practice activities were relevant to this information. Students were encouraged to think back to the traditional pictures to facilitate retrieval, and no reference was made to mnemonic strategy information.

Dependent Measures

At the end of each week of instruction, students were individually administered a test of the week's content, as well as cumulative content to date. At the end of the five weeks of instruction, students were given an individually-administered, comprehensive test of all states and capitals covered during this period. Students were asked to provide the appropriate capital name, when given a state name, and then were asked to provide a state name, when given a capital name. No feedback on the correctness of responses was given during any section of the test. After the test was completed, students were asked how they had remembered the capital of each state, as the examiner asked, for example, "How did you remember the capital of Alabama?" Verbatim responses were recorded. State and capital responses were scored either correct or incorrect, and strategy reports were assigned a nominal value depicting the type of strategy reported. Two raters discussed and resolved any disagreements in scoring strategy data.

Finally, students were given a questionnaire, in which their own opinions of the two types of instruction (mnemonic or traditional) were solicited. They were asked which instructional procedure they enjoyed more, in which procedure they had learned more, which procedure they would prefer to have again, and in which procedure had they paid more attention.

Results

Recall Tests

Because the number of test items for mnemonic and traditionally instructed content was not equivalent across classrooms (i.e., one classroom had three mnemonic and two traditional weeks of instruction, while the other had two mnemonic and three traditional weeks of instruction), scores were converted to percentages. For the five-week cumulative recall test, students were assigned one score for the percent of mnemonically instructed information answered correctly, and one score for the percent of traditionally instructed information answered correctly, for both capital and state information. Students remembered 72.9% (SD = 22%) of mnemonically instructed capital names, compared with 43.4% (SD = 27%) of traditionally instructed capital names. In addition, students recalled 79.6% (SD = 22%) of mnemonically instructed state names, compared with 50.7% (SD = 28%) of traditionally instructed state names. Capital and state test scores by classroom and week in which the content was introduced are presented in Figures 4 and 5, respectively. In each of these figures, the solid line represents Classroom A and the dashed line represents Classroom B. Within each of these classrooms, the open square represents a score of mnemonically instructed items, while the "+" symbol represents a score of traditionally instructed items. As can be seen, each classroom produced dramatically higher scores when mnemonic instruction was employed, followed in each case by substantially lower scores for traditionally instructed items, on alternate weeks.

Insert Figures 4 and 5 about here.

Data were entered into a two condition (mnemonic vs. traditional) by two response (state vs. capital) analysis of variance (ANOVA), which yielded significant main effects for condition, $F(1,18) = 31.16$, $p < .001$, and response, $F(1,18) = 19.87$, $p < .001$. No condition by response interaction was observed, $F(1,18) = 0.00$, $p = 1.000$. [Parallel analyses using arcsine-transformed data (Ferguson, 1981) yielded comparable results]. Across students, recall of capital names strongly predicted recall of state names, Pearson $r = .948$, $p < .001$.

Because of the poor attendance in this low-SES, inner-city school, ten of the 29 students were not available to take the five-week cumulative recall tests. Nevertheless, performance of this subsample paralleled the results presented above. Weekly scores under mnemonic instruction exceeded weekly scores under traditional instruction for all of these students during the weeks for which they were in attendance more than one day.

Strategy Reports

Student responses were awarded one point for each item for which they reported an appropriate mnemonic strategy. Reported mnemonic strategy scores were positively and significantly correlated with performance on mnemonically instructed items, Pearson rs $= .755$, $p < .001$, and $.671$, $p = .001$, for state and capital information, respectively.

For traditionally instructed items, the most common strategy report was, "I don't know" (56.4%). No complete keyword-keyword mnemonic strategies were reported by any student for items which had been traditionally instructed, indicating no spontaneous transfer of these strategies across weeks of instruction. It is worthy of note, however, that one student did report a number of keyword-like elaborations for either stimulus or response information taught under traditional instruction, and, although these strategies were incomplete, they nevertheless resulted, for this student, in high (97% correct) levels of recall.

Survey Information

Of the nineteen students surveyed, 15 reported that they preferred mnemonic to traditional instruction, 17 reported that they had learned more, 16 reported they would like to receive additional mnemonic instruction, and 17 reported they had paid attention more under mnemonic instruction. In addition, both regularly assigned special education teachers reported that they preferred mnemonic instruction and felt that students had learned more and enjoyed instruction more when mnemonic materials and procedures were employed. These teachers requested copies of mnemonic states and capitals materials for use in future years.

Discussion

The results of this investigation suggest that mnemonic instructional methods and materials can be profitably employed in special education classrooms to enhance greatly the learning of U.S. states and capitals. Since mastery of states and their capitals constitutes an important component of regular junior high or middle school curriculum, these procedures could be very beneficial in helping LD students meet the demands of mainstream curriculum (see also Scruggs & Mastropieri, in press b).

Although forward and backward recall of mnemonically instructed information has not been previously evaluated in special education settings, it was found that students learned more under mnemonic instruction, whether recall of the information was requested in either forward (capital) or backward (state) formats. Apparently, under extended instructional procedures, students are able to respond correctly to target information asked in different ways. This finding does not support a commonly-heard objection that mnemonic instruction only allows students to "parrot" back responses that have been asked in a specific way. Although other research has also provided evidence that mnemonically instructed students can effectively apply learned information in different contexts (e.g., Mastropieri, Scruggs, & Fulk, 1990; Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1987; Veit, Scruggs, & Mastropieri, 1986), this is the first investigation in which forward and backward recall was directly assessed.

In addition, the present investigation is the first which directly tested the application of a complex keyword-keyword strategy with learning disabled students. The outcome was far from a foregone conclusion, as much of the information was unfamiliar and/or abstract to learners, and the use of two mnemonic reconstructions within one illustration may have exceeded the information-processing capabilities of these learners. The present results suggest that these and other complex mnemonics can be used profitably with learning disabled students.

In addition to the statistically significant differences in recall, a relatively large and educationally meaningful difference was observed across conditions. This difference, from an average of 47% correct to 76% correct, is equivalent to the difference between an 'F' and a 'C' on a standard report card grade. This magnitude of difference, then, represents the difference between passing and failing, and consequently, maintaining successful progress toward high school graduation. Similar performance differences have been seen in other classroom applications of mnemonic instruction (Scruggs & Mastropieri, 1989) and are quite comparable to those reported in a recent quantitative synthesis of mnemonic instructional research (Mastropieri & Scruggs, 1989a).

An additional finding was that, across conditions, students remembered state responses better than they recalled capital names. The lack of a statistical condition by response interaction suggests that this difference was consistent across conditions and may be attributable to students' greater familiarity with state names. In future applications, additional practice with capital names may be helpful in increasing familiarity of these names.

As with previous research reports (e.g., Mastropieri & Scruggs, 1988, 1989b; Scruggs & Mastropieri, in press b) students reported an overwhelming preference for mnemonic instructional methods and materials. They have consistently reported not only enjoying the instruction more, but also attribute their increase in learning to these procedures. This is an important finding, for students are not likely to exhibit persistence of effort over time with instructional strategies which they dislike, or strategies which they do not believe are helpful.

Also consistent with previous research reports (e.g., Mastropieri & Scruggs, 1988), little or no evidence of spontaneous strategy generation was observed under traditional instruction, even when such instruction was immediately preceded by a week of mnemonic strategy instruction. Although LD students enjoyed mnemonics and appreciated their value, they apparently did not develop such strategies when they were not provided by teachers. This finding is in accordance with generalization problems commonly noted in special education settings (e.g., Scruggs & Mastropieri, 1984), but, in the case of mnemonics, may also underline the difficulty level involved in generating such strategies.

In spite of the lack of spontaneous strategy transfer noted in this and previous investigations, some prior evidence of mnemonic strategy transfer in classrooms has recently been obtained. Scruggs and Mastropieri (in press a) reported that students were able to generate effective mnemonic pictures, under group instruction with teacher guidance and prompting. Similarly, Fulk (1990) reported that LD students were able to transfer mnemonic strategies under guided and prompted conditions. Additionally, Fulk reported that, after several days of intensive individual instruction, LD students were able to transfer mnemonic keyword strategies several weeks later to substantially different content without prompting or guidance. Nevertheless, both reports noted that students had learned more content more easily when mnemonic strategies were explicitly provided to students. Such findings suggest that mnemonic materials development may be an important skill for special education teachers to develop.

The total time spent in instruction of states and capitals in this investigation paralleled the amount of instructional time allocated to students in special education and mainstream social studies classes. Nevertheless, in future classroom applications it may be possible to reduce the amount of classroom instructional time. In the present investigation, we did not allow experimental instructional materials outside the classroom, in order to control for total time of exposure and ensure that cross-condition contamination did not occur. However, in non-experimental applications, worksheets could be assigned as homework activities, and classroom time saved in this way could be used for instruction of additional social studies content.

In sum, the present investigation adds to the accumulating evidence that supports the use of mnemonic instructional strategies with learning disabled students for learning a variety of content. In addition, important new information has been obtained on the use of a keyword-keyword strategy and forward vs. backward recall. Although additional research remains to be conducted, at present it appears that mnemonic instruction is a viable and important technique for improving the school success of learning disabled students.

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Figure Captions

Figure 1. Mnemonic illustration depicting Madison as capital of Wisconsin.

Figure 2. Traditional illustration depicting Madison as capital of Wisconsin.

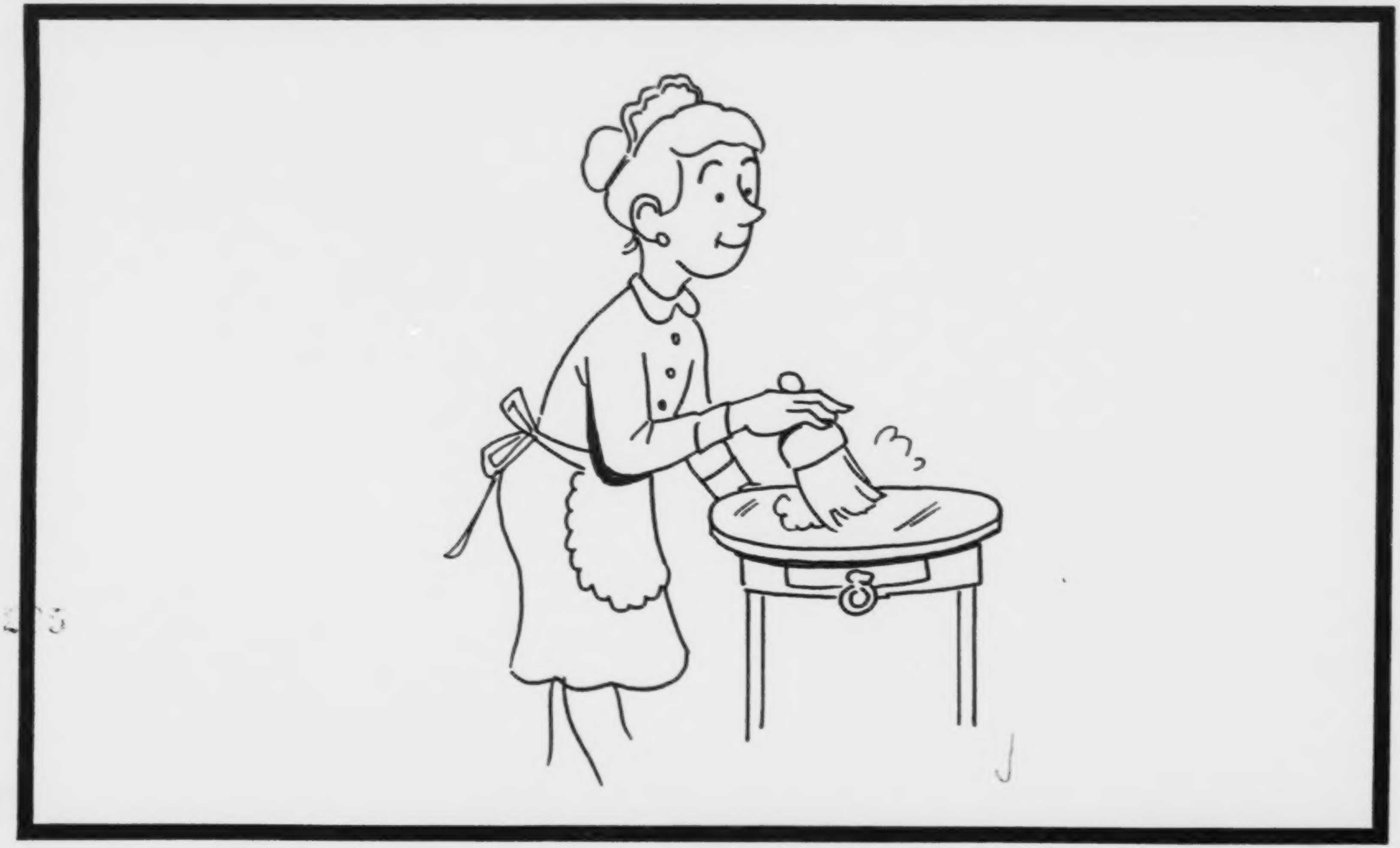
Figure 3. Sample dialogue from mnemonic lesson.

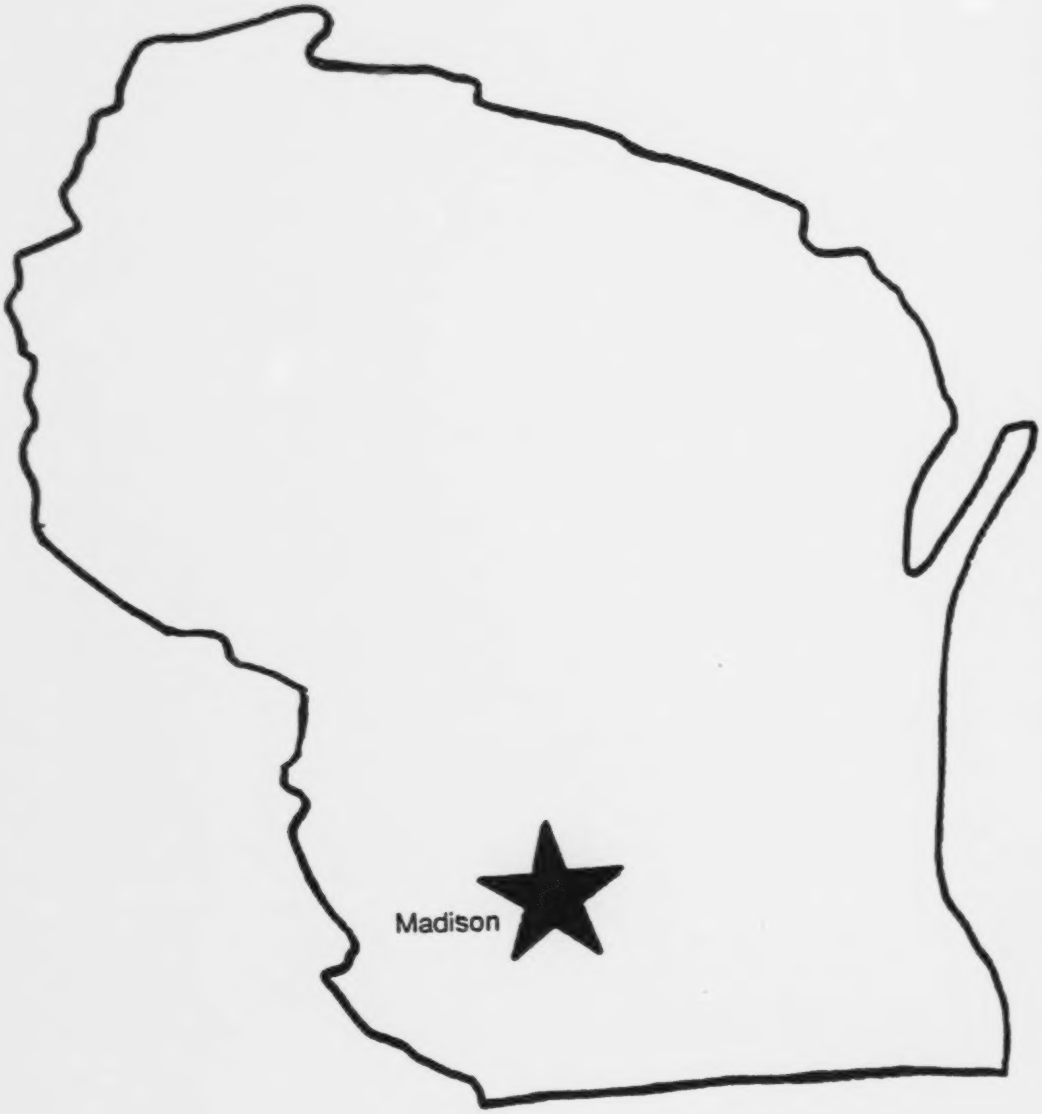
Figure 4. Fifth week recall scores by class, condition, and order of presentation of capital responses.

Figure 5. Fifth week recall scores by class, condition, and order of presentation of state responses.

Wisconsin
(whisk broom)

Madison
(maid)




Madison

States and Capitals

Daily Review Teacher: Let's practice the states and capitals we have covered so far in class. Everybody, what's the capital of Maine? [Students respond]. . . . .

Present new info. Teacher: The capital of Wisconsin is Madison. The keyword for Wisconsin is whisk broom [Points to overhead projection of mnemonic illustration]. Here is a picture of a whisk broom. The keyword for Madison is maid [Points to overhead]. Here is a picture of a maid.

The important thing to remember is a maid using a whisk broom. What is the keyword for Wisconsin? [Students respond]. Good. What is the keyword for Madison? [Students respond]. Good. Remember, when I ask you for the capital of Wisconsin, first think of the keyword, which is? [Students respond]. Good, whisk broom. Then, think of the picture with the whisk broom in it. What is in that picture? [Students respond]. Good, a maid is using the whisk broom. And what is maid the keyword for? [Students respond]. Good, maid is the keyword for Madison. So what is the capital of Wisconsin? [Students respond]. Good, Madison. What is the important thing to remember about this picture? [Students respond].

Guided Practice Now, if I ask you to tell me the capital of Wisconsin, what is the first thing you should think of?

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__Student__: The keyword.

__Teacher__: Right, and the keyword is --?

__Student__: Whisk broom.

__Teacher__: What's the second thing you should think of?

__Student__: What's happening in the picture.

__Teacher__: And what is happening in the picture?

__Student__: The maid is using a whisk broom.

__Teacher__: That's right. And what's the other keyword?

__Student__: Maid.

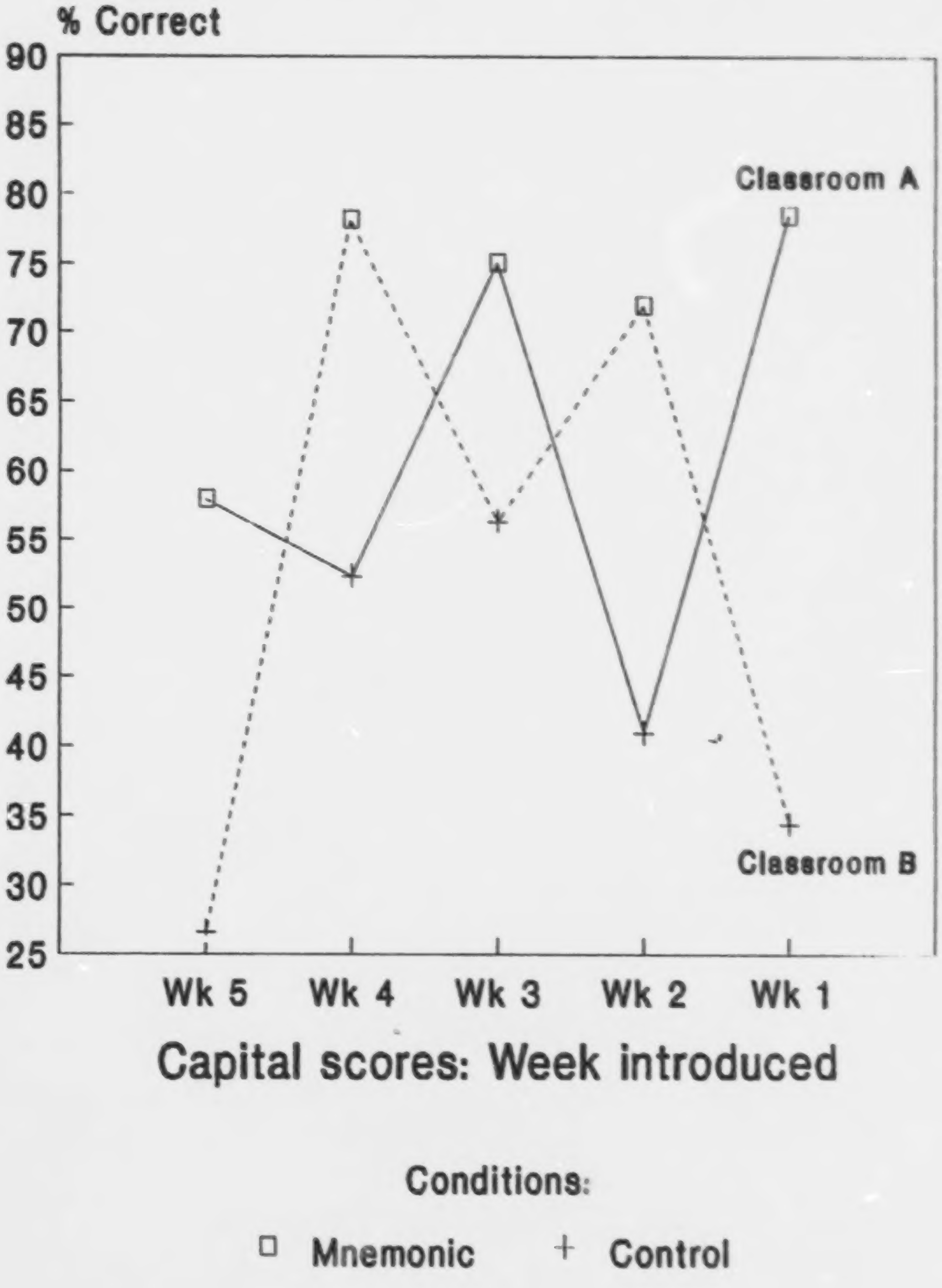
__Teacher__: And what does that stand for?

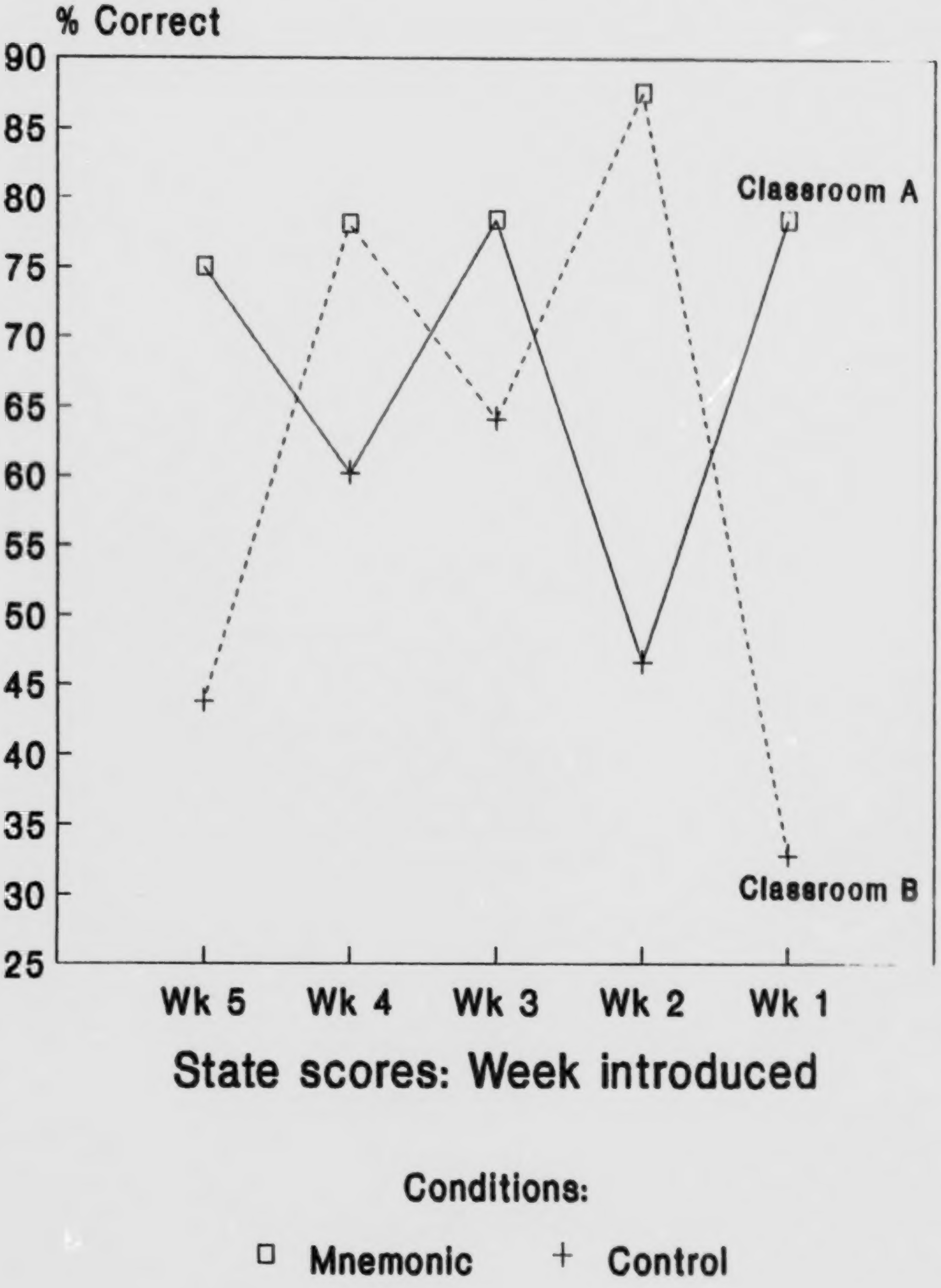
__Student__: Madison.

__Teacher__: Madison, correct. [Repeat questioning for "Madison is the capital of what state?]. . .

Ind. Practice Now I will pass out a worksheet and go over how you complete it. . . .

Form. Eval. Now let's review your answers on the worksheet we just completed. . .


% Correct
90
85
80
75
70
65
60
55
50
45
40
35
30
25
Classroom A
Classroom B
Wk 5
Wk 4
Wk 3
Wk 2
Wk 1
Capital scores: Week introduced
Conditions:
□ Mnemonic
+ Control


% Correct
90
85
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Classroom A
Classroom B
Wk 5
Wk 4
Wk 3
Wk 2
Wk 1
State scores: Week introduced
Conditions:
□ Mnemonic
+ Control

Appendix M

Mastropieri, M.A., Scruggs, T.E., & Fulk, B.J.M. (1989). Teaching abstract vocabulary with the keyword method: Effects on recall and comprehension. *Journal of Learning Disabilities, 23*, 92-107.

Editor's Comment:

The purpose of the Interventions section of the journal is to provide professional practitioners with overviews of successful interventions that can be replicated with individuals with learning disabilities. These interventions can be either physiological or psychoeducational and can occur in school settings, clinics, hospitals, homes, communities, or employment sites. The discussion of these interventions generally includes (a) the theory or rationale of the interventions, (b) previous research findings, (c) characteristics of the individuals receiving the interventions, (d) the intervention that was applied, and (e) the criteria used to evaluate its success. In the following article, Margo A. Mastropieri, Thomas E. Scruggs, and Barbara J. Mushinski Fulk, of Purdue University, describe a technique for teaching vocabulary with the keyword method. Using this strategy, a sample of students with learning disabilities had significantly higher levels of recall and comprehension than when a rehearsal strategy was employed. Results suggest that a keyword method can be successfully employed in teaching vocabulary. —**JLW**

Teaching Abstract Vocabulary with the Keyword Method: Effects on Recall and Comprehension

Margo A. Mastropieri, Thomas E. Scruggs,
and Barbara J. Mushinski Fulk

Twenty-five adolescents with learning disabilities were randomly assigned to either a keyword mnemonic condition or an experimenter-directed rehearsal condition and were individually taught 16 difficult vocabulary words, including 8 concrete and 8 abstract words. After an instructional period, students were given a test of literal recall as well as a comprehension test of their ability to apply newly acquired vocabulary words in a different context. Results indicated that mnemonically trained students outperformed control students on both abstract and concrete words, and on recall tests as well as on comprehension tests. Implications for vocabulary instruction as well as theories of learning disabilities are discussed.

Present-day theorizing in learning disabilities has suggested that much of the observed performance differences between students with learning disabilities (LD) and nondisabled students on memory tasks may be language based (Baker, Ceci, & Herrmann, 1987; Scruggs, 1988). Vellutino and Scanlon (1982, 1985), for example, described a series of research studies that consistently indicated that students with LD and nondisabled students did not differ with respect to associative learning on nonverbal tasks; however, when the tasks included a verbal component, performance differences favored nondisabled students. Swanson (1987) argued that the inability of students with LD to name unfamiliar pictorial information, or profit from the external imposition of a name, results in differentially lower memory performance. In contrast, students with LD may perform normally on recall of unnamed figural information.

Baker et al. (1987) described research that suggests that students with LD do not exhibit deficits on gross measures of semantic memory, such as single-word comprehension or word association tasks. However, deficits were exhibited on more finite tasks, such as lexical access (access to isolated vocabulary information), name retrieval, and language-based strategy use. Baker et al. argued that deficiencies in the *structure* of semantic memory (i.e, how verbal information is stored and organized) result in lessened ability to name, describe, and remember verbal information. In addition, the *process* of semantic memory (i.e., operations carried out on semantically stored information) has also been shown to be deficient and may account, at least in part, for observed deficits in the structure of semantic memory. This dual deficiency in prior language knowledge (structure) and ability to acquire new verbal information (process) can result in a negative instance of what Walberg and Tsai (1983) referred to as the "Matthew effect." That is, the less students with LD learn (because of verbal encoding and storage deficits), the less they are able to learn (because of an impoverished knowledge base).

Kail and Leonard (1986) attributed the word-finding problems of a subset of disabled learners to the inadequate representation of words in memory. In addition, Kail and Leonard reported basic deficiencies in retrieval of language-based information. In discussing future research endeavors, they concluded that "research should be based as much on the quest for instructionally relevant information as on the search for differences between learning-disabled children and their peers on tasks that are state-of-the-art but instructionally vacuous" (p. 200).

Clearly, there is a need for language-learning strategies to serve the multiple deficit areas of students with learning disabilities. First, students with LD need to improve their impoverished store of verbal information (Pressley, Johnson, & Symons, 1987). A larger, more extensive language base could help learning disabled students cope more efficiently with new verbal information. Second, students with LD need to be taught more efficient means of acquiring new verbal information. These two purposes address the issues of structure and process deficiencies described by Baker et al. (1987). Ceci (1985) provided evidence that students with LD are relatively deficient at purposive, rather than automatic, semantic processing. He argued that these findings

> . . . suggest that instead of advocating intervention plans that are directed at remediating alleged cerebral insult or dysfunction, a more

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> profitable approach to children with semantic processing difficulties . . . is to train purposive information-processing strategies like elaborative encoding, chunking, anticipation, type 2 rehearsal, and so on. (Ceci, 1985, p. 219)

One such elaborative vocabulary-learning strategy that has received recent research attention with students with LD is the *keyword* method (Mastropieri, 1988). First described by Atkinson (1975), the keyword method reconstructs unfamiliar verbal stimuli into acoustic representations, and elaborates the transformed stimuli with the response information. For example, to learn that *oxalis* is a clover-like plant, learners can first be provided with an acoustically similar keyword, such as *ox*. In this case, *ox* is a good keyword because it sounds like oxalis and is easily pictured. Next, a picture can be shown in which an ox is eating clover-like plants. Learners are told, when asked for the meaning of oxalis, that they should first think of the keyword, *ox*, then think back to the picture of the ox, think of *what else* is happening in the picture, and provide the response, a clover-like plant. These three steps of Recoding, Relating, and Retrieving have been referred to as the "three Rs" of mnemonic keyword instruction (Scruggs, Mastropieri, Levin, & Gaffney, 1985).

Several recent investigations have evaluated the effectiveness of the keyword method in facilitating the vocabulary learning of students with LD. Taylor (1981) provided some initial evidence that the keyword method was highly effective in teaching vocabulary information to a sample of boys with LD, but a methodological flaw inhibited unequivocal conclusions from this study (see Mastropieri, Scruggs, & Levin, 1987, for a discussion). In two experiments, Mastropieri, Scruggs, Levin, Gaffney, and McLoone (1985) taught middle school students with LD a list of 14 English vocabulary words, using either a keyword condition or an experimenter-led drill-and-practice (direct instruction) condition. In the first experiment, the keyword condition students were provided with keywords and interactive pictures, and in the second experiment, the keyword condition students were asked to generate their own interactive images. In both experiments, keyword condition students greatly outperformed direct instruction condition students, although in the second experiment the performance differential was somewhat lower.

McLoone, Scruggs, Mastropieri, and Zucker (1986) again compared keyword instruction and a direct instruction rehearsal condition with adolescents with LD who were learning both native English and Italian vocabulary words. In the first task, instruction was experimenter directed for both conditions. In the second task, students in both conditions were given instruction in strategy transfer and asked to apply their respective strategies to a new list of words. The keyword condition students again outperformed the direct instruction rehearsal students on both tasks. In a fourth investigation, Veit, Scruggs, and Mastropieri (1986) taught, among other things, Greek root words relevant to the study of prehistoric reptiles (e.g., *ptero*, meaning "winged"; *saur*, meaning "lizard") to middle school students with LD using the keyword method or experimenter-led drill and practice. The keyword condition students not only learned more meanings than the direct instruction condition students, but were also more able to apply the information when entire prehistoric reptile names were provided (e.g., *pterosaur*, meaning "winged lizard").

Finally, Condus, Marshall, and Miller (1986) evaluated the efficacy of the keyword method when applied to existing curriculum materials and taught by special education teachers over time in their own classrooms. It was found that students with LD taught via the keyword method scored consistently higher than controls on a series of recall tests administered over a 5-week instructional period, and they maintained this advantage over a 10-week delayed recall period.

In spite of these initial successes of the keyword method as a means of facilitating vocabulary learning of students with LD, several questions have yet to be answered, two of which are addressed in the present investigation. First, can the keyword method be used to teach abstract as well as concrete information? The studies reported by Taylor (1981), Mastropieri et al. (1985), and McLoone et al. (1986) all employed concrete words, while Condus et al. (1986) did not report whether abstract words had been used, and did not analyze their results by levels of concreteness or abstraction. Since the keyword method is pictorial, that is, it relies upon pictured reconstructions of response information, a case could be made that this method could not be adapted to abstract vocabulary. Furthermore, Graves (1986) suggested that the keyword method may be suitable only for learning new labels for already-familiar words, and Johnson, Adams, and Bruning (1985) provided some empirical evidence that the keyword method may not facilitate the learning of abstract vocabulary.

A second issue that has yet to be addressed concerns the level of comprehension induced in students with LD taught via the keyword method. It is possible, for example, that students with LD can readily acquire vocabulary via the keyword method, but can only employ this information on simple recall tasks, such as those used in the above experiments. In other words, the keyword method may not be useful in teaching vocabulary that is expected to be used in other contexts. It is true that students in the Veit et al. (1986) investigation were able to define word parts that were combined into larger, complete words; nevertheless, this was a relatively simple transfer task and was not a true measure of the students' ability to use newly acquired vocabulary within a semantically different context. This potential problem with nondisabled learners may be of particular importance to special education students, who are known for exhibiting problems with generalization of learned academic and social behavior (Scruggs & Mastropieri, 1984).

In order to address these two important issues, we employed in the present experiment a vocabulary list that contained both concrete and abstract words. In fact, these words were taken directly from a study in which it had been concluded that the keyword method was not effective with abstract words (Johnson et al., 1985). Second, after a production test in which learners were asked to provide the meanings of the new words they had learned, they were given a comprehension test, which measured their ability to adapt their newly acquired vocabulary to semantically novel instances.

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METHOD

Subjects

Subjects were 25 students with LD who attended resource rooms in either a small town or small city in the Midwest. Students had been previously classified as learning disabled according to state and federal guidelines, which included normal intelligence coupled with demonstrable difficulties learning school-related content, presumably not due to emotional disturbance, sensory impairment, or socioeconomic disadvantage. All students had been referred initially by regular classroom teachers for failure to learn and were characterized as learning disabled on the basis of a multidisciplinary meeting in which a variety of intellectual, social, and academic factors were taken into account. Average score on the Wechsler Intelligence Scale for Children–Revised (WISC-R) (Wechsler, 1974) for the sample was 92.5 (*SD* = 11.4); average reading grade equivalent, as assessed by the Wide Range Achievement Test–Revised (WRAT-R) (Jastak & Jastak, 1978), was 5.0 (*SD* = 1.3); average math grade equivalent, as assessed by the WRAT-R, was 5.0 (*SD* = .9); average picture language vocabulary standard score, as assessed by the Quick Test (Ammons & Ammons, 1962) during this investigation, was 91.9 (*SD* = 15.0). The sample included 17 boys and 8 girls, of whom 5 were sixth graders, 9 were seventh graders, and 11 were eighth graders. Mean age was 14 years, 1 month (*SD* = 18 mo.); all subjects were Caucasian.

Materials

Vocabulary words used in this investigation were taken from a somewhat larger list provided by Johnson, Adams, and Bruning (1985), and included eight concrete (e.g., *oxalis, carnelian, soutache*) and eight abstract (e.g., *vituperation, octroi, nescience*) words. An additional two words (one concrete, one abstract) were used for practice examples. Materials specific to each condition are now described.

Keyword Condition. Materials for the keyword condition consisted of eighteen, 8½ in. x 11 in. index cards. On top of each card were printed the vocabulary word, keyword in parentheses, and definition. In the middle of each card, the keyword was pictured interacting with its definition in a line drawing. For example, for *oxalis*, meaning clover-like plant, an ox (keyword for oxalis) was pictured eating clover-like plants. For abstract words, the keyword was pictured interacting with an instance of the definition. For example, for *octroi*, meaning a tax paid on goods upon entering a town, an octopus (keyword for octroi) was pictured collecting taxes from persons entering a town. For *vituperation*, meaning abusive speech, a viper (keyword for vituperation) was pictured speaking abusively to someone.

Rehearsal Condition. Materials for this condition were the same as those for the keyword condition, with the exception that any keywords or pictured references to keywords were omitted. For example, the oxalis picture omitted the ox, and the octroi picture presented a person, rather than an octopus, collecting taxes from people entering a town. With this exception, the drawings and lettering were identical to the materials used in the keyword condition.

Tests. Two tests were constructed for this investigation. One was a literal recall test, where students were asked to produce orally the definition of each vocabulary word, for example, "What does *vituperation* mean?" The second test was a comprehension test, in which students were asked, in a matching format, to provide the appropriate vocabulary word, given a novel instance of the word. For example, a sentence such as, "A teacher may speak this way to a child who misbehaves," or, "When you water a plant, it grows this," was presented, and the student was asked to identify the relevant vocabulary word.

Procedure

As the students entered a quiet area adjacent to their classrooms, they were stratified by grade level and assigned at random to either the keyword or the direct instruction condition. All students were seen individually by one of two female examiners, each of whom delivered an equivalent number of treatments from each condition. After being administered the Quick Test, the students were told that they were going to learn some new vocabulary words, and that they should try their best because they were going to be given a test at the end of the lesson. Each student, regardless of experimental condition, spent the same amount of time with the examiner, including administration of the Quick Test (2 min.), instruction of practice and target information (13 min.), and a 1-minute filler interval prior to the recall and comprehension tests. No time limits were placed on the test administrations. Procedures unique to each condition are described below.

Keyword Condition. Students were first taught keywords for the two practice examples. They were then shown the mnemonic pictures for each new vocabulary word and asked to look at them while the experimenter said, for example, "The keyword for *chiton* is *kite. Chiton* means 'loose garment.' Remember this picture of people making kites out of their loose garments." The students were then asked the definition of the vocabulary word, and asked to describe the picture. Students were shown each of the two practice pictures for 30 seconds. After the practice examples had been shown, the students were given a practice production test and comprehension test on the items. Students were given feedback on their answers.

Following the practice test, students were taught the keywords and shown the 16 target vocabulary words, presented in a randomized order. Students were shown each picture for 30 seconds while the experimenter described the keyword and the pictorial strategy as described above. Again, students were asked to provide the definition of each new vocabulary word once and to describe the interactive picture once. At the end of the training picture, students were given the production recall test, followed by the comprehension test.

Rehearsal Condition. This condition was selected as a best available alternative treatment condition (Borkowski & Buchel,

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1983), and was implemented as employed in previous vocabulary training studies (Mastropieri, Scruggs, & Levin, 1985). This type of vocabulary teaching strategy was described by Carnine and Silbert (1979) as a "commonsensical approach": "The teaching procedure involves first telling the student the definition and having them repeat it" (p. 149). In this condition, students were individually taught the two practice examples using the labeled pictures and procedures described above. For example, "*Chiton* means loose-fitting clothing; what does *chiton* mean?" Drill and practice was provided on these two words, followed by a practice recall and comprehension test, as in the keyword condition.

Following the practice test, students received a brief preview of the target vocabulary words, during which they practiced pronouncing the words. This activity replaced the keyword learning activity in the keyword condition. Students were then given instruction in the 16 vocabulary words, using experimenter-led drill and practice, rapid-paced questioning, and corrective feedback. Students received, as in the keyword condition, 30 seconds on each of the 16 words. In this condition, however, an additional minute was spent on a review of all words. As this review period replaced the time spent on initial learning of keywords in the keyword condition, the rehearsal condition students actually received *more* time for learning target information. Total time with the experimenter, however, was equivalent across conditions.

Both Conditions. Following the instructional period, which was equal in time for both groups, students were given a 1-minute activity in which they were asked to write their name, grade, birth date, school, and teacher's name. Following this activity, all students were given, individually, the production recall test, followed by the comprehension test. For both tests, the experimenter read the questions aloud to the student and recorded the responses verbatim on the answer sheets.

Scoring. Answer sheets were scored by two experimenters, blind to experimental condition, who reached 100% agreement. Responses on the recall test were awarded 1 point for completely accurate answers, one-half point for incomplete answers that nonetheless contained some critical aspect of the target response (for example, for *buncombe*, "speech" rather than "boring or empty speech"). The comprehension test employed identification format, in which answers were either correct or incorrect; therefore, no partial credit was given.

RESULTS

Means, standard deviations, and obtained effect sizes are provided in Table 1. Data were entered into a two condition (keyword vs. direct instruction) by two item type (abstract vs. concrete) analysis of variance (ANOVA), with repeated measures on the item type variable (Winer, 1971) for the production recall task, as well as for the comprehension task. Results indicated that the mnemonically instructed students outperformed the rehearsal condition students on both the production test, $F(1,23) = 47.69$, $p = .000$, and the comprehension test, $F(1,23) = 5.66$, $p = .026$. An additional main effect was found for item type on the production test, with students performing higher on concrete words, $F(1,23) = 10.28$, $p = .004$. On the comprehension test, no effect was found for item type, $F(1,23) = .01$, $p = .937$, perhaps due to the identification format. The item type by condition interaction was not statistically significant on either the production test, $F(1,23) = .25$, $p = .619$, or the comprehension test, $F(1,23) = .60$, $p = .448$.

DISCUSSION

Results of this investigation indicate that keyword mnemonic instruction resulted in higher levels of recall and comprehension than a rehearsal condition. This study in part replicates previous findings that students with LD learn substantially more concrete vocabulary when taught by the mnemonic keyword method than when taught by more traditional drill-and-practice methods. In addition, it represents an important extension into the areas of abstract vocabulary learning and vocabulary comprehension.

The abstract vocabulary words chosen were taken from a previous investigation with college undergraduates by Johnson et al. (1985), who concluded that the keyword method was effective in facilitating learning of concrete words, but ineffective in facilitating learning of abstract vocabulary words. Pressley and Levin (1985) argued that methodological problems in the implementation of that study may have accounted for the lack of effectiveness of the keyword method; nevertheless, in the present investigation, students with LD who were instructed mnemonically easily learned both abstract and concrete words. The lack of obtained item type by condition interaction suggests that the keyword method was equally effective, as compared with a rehearsal condition, for both abstract and concrete vocabulary words.

Mnemonic keyword instruction also resulted in higher levels of comprehension, as measured by an application task in which students were asked to provide appropriate vocabulary words in novel (to the learner) instances of the words. This finding is of importance, for it may have been argued that the keyword method facilitates literal recall of new vocabulary definitions at the expense of the ability to use the vocabulary in any different context. It does not appear that there is anything in the keyword method

TABLE 1
Means, Standard Deviations, and Effect Sizes

Comparison	Keyword condition	Rehearsal condition	Effect size
Production test	10.67 (2.9)[a]	3.54 (2.2)	3.25
Abstract items	4.96 (2.0)	1.19 (1.1)	3.43
Concrete items	5.71 (1.7)	2.34 (1.6)	2.11
Comprehension test	13.08 (2.5)	8.15 (2.7)	1.83
Abstract items	6.67 (1.4)	3.92 (1.4)	1.96
Concrete items	6.42 (1.5)	4.23 (1.9)	1.15

[a] Standard deviations in parentheses.

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per se that facilitates greater initial comprehension than alternative instructional procedures; the results of this investigation seem to suggest that students taught vocabulary via the keyword method are better able to use new vocabulary words because they have initially learned more words that could be of use in such an application task. Taken with the results of the Veit et al. (1986) investigation, this investigation seems to indicate that there is no observed comprehension "trade-off" resulting from mnemonic instruction. This finding is further validated by the results of an investigation involving science facts rather than vocabulary learning (Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1987). In that investigation, students with LD who had been taught mnemonically specific attributes of North American minerals (e.g., specific hardness level, specific color, specific use) were more able than control subjects to infer attribute dichotomies (e.g., soft vs. hard, light color vs. dark color, home use vs. industrial use). The fact that mnemonically instructed students with LD have been shown to comprehend and learn both abstract and concrete information demonstrates that mnemonic instruction has great promise as a viable instructional alternative. Although long-term retention of learned information was not addressed in the present investigation, previous research has demonstrated that mnemonically instructed students with LD maintain their initial learning advantage for extensive delay intervals, such as 3 to 4 days (Scruggs & Mastropieri, in press), 1 week (Scruggs et al., 1987), 8 weeks (Mastropieri & Scruggs, 1988), and 10 weeks (Condus et al., 1986).

The success of the mnemonic keyword method may be due, in part, to an interaction of the properties of mnemonic instruction with the particular characteristics of students with LD. First, since the semantic knowledge base of students with LD has been shown to be impoverished relative to nondisabled students, strategies such as the keyword method that do not place excessive demands on prior knowledge may be expected to optimize learning. Second, since it has been reported that acoustic encoding developmentally precedes semantic encoding (e.g., Torgesen & Kail, 1980), a method that relies upon the encoding of acoustic similarities (e.g., oxalis = ox, in the example above) is more likely to be effective with students with LD, who may exhibit delays in language development.

Third, the keyword method may provide additional support for students with LD who have particular difficulty with abstract vocabulary. Vellutino and Scanlon (1985) reported that students with LD learned concrete information more efficiently than abstract information; at lower age levels, students with LD were differentially lower than nondisabled controls at learning abstract vocabulary words. The keyword method has been effective in reconstructing unfamiliar or abstract stimulus and response information into more familiar, concrete, pictorial representations. In the present investigation, the keyword method was successful in reconstructing concrete proxies for abstract vocabulary words and their definitions. The increased learning that resulted was also effectively applied to novel instances of the vocabulary concept.

Finally, the keyword method appears to be effective for learners who are able to use visual imagery effectively. Although previous researchers have suggested that some students with LD may be unable to use visual imagery (e.g., Kirk & Kirk, 1971), research conducted to date on the keyword method has suggested that this is not the case, at least for a large number of students characterized as learning disabled. Other previous theories of learning disabilities that do not appear to be supported by the results of mnemonic research are described by Scruggs, Mastropieri, and Levin (1987).

Further research employing comparison samples of nondisabled students can provide additional information on any differential facilitation of the keyword method on the part of students with learning disabilities. However, the above arguments are not intended to suggest that keyword-based mnemonic instruction is beneficial only for students with learning disabilities. It has been seen, for example, that the keyword method can be effective in teaching vocabulary words to students with mental retardation (Scruggs, Mastropieri, & Levin, 1985) and behavioral disorders (Mastropieri, Emerick, & Scruggs, 1988), as well as to gifted students (Scruggs, Mastropieri, Jorgensen, & Monson, 1986). Nevertheless, given the high level of success obtained to date, the keyword method appears to be especially suitable for addressing the specific learning characteristics of students with LD, particularly as they pertain to deficits in semantic memory.

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AUTHORS' NOTES

This research was supported in part by grants from the U.S. Department of Education, Nos. G008730144-88 and H029D80034. The authors thank Susan Evans and the students of Maconaquah Middle School for their assistance with the research reported here.

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Appendix N

Pressley, M., Scruggs, T.E., & Mastropieri, M.A. (1989). Memory strategy research in learning disabilities: Present and future directions for researchers. Learning Disabilities Research, 4, 68-77.

Memory Strategy Research in Learning Disabilities: Present and Future Directions

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This article addresses what is regarded as unjustifiably pessimistic characterizations of memory strategy instructional research, as exemplified most recently by Shepherd and Gelzheiser (1987). These notions are discussed with respect to four major research questions regarding memory strategy instruction and learning disabilities (LD): (a) Do LD students "spontaneously" use memory strategies? (b) Can LD students learn to use memory strategies? (c) Can LD students learn to use memory strategies generally and appropriately? (d) Can classroom materials and instructional procedures be modified to provide the advantages of strategy instruction? It is argued that, for practical as well as scientific reasons, a solid foundation of laboratory research on strategy use is needed before issues of classroom applications and materials modifications can be addressed. It is also maintained that, though incomplete, much memory instructional research with direct classroom applications has already been completed. Finally, a rational model for the most efficient sequence of research efforts in memory strategy instruction is presented.

A great deal of attention has recently been given to strategy instruction. There have been many carefully reasoned discussions of strategies that present what is known and what remains to be learned, particularly with respect to average or above-average learners (e.g., Nickerson, Perkins, & Smith, 1985). Some claims were much more optimistic than the extant data base justified (see Mayer, 1986; Pressley, Cariglia-Bull, & Snyder, 1984; Pressley, Goodchild, Fleet, Zajchowski, & Evans, in press, for discussion). On the other hand, some individuals seem unjustifiably pessimistic. One purpose of this article is to provide constructive discussion of one such negative review concerned specifically with memory strategy instruction and placed prominently in the LD literature (Shepherd & Gelzheiser, 1987). The major purpose of this article, however, is to provide a statement about four questions that memory strategy researchers should be asking with respect to instruction of LD students. The first two questions address the issue of spontaneous and independent strategy use and can be investigated through laboratory-based research. The second two questions are applied and necessitate classroom-based research. While considering these questions, the research progress that has been made to date is also discussed. Research on mnemonically mediated instruction for LD students is emphasized, since Shepherd and Gelzheiser (1987) questioned explicitly the value of associative mnemonics research (e.g., work on the keyword method).

The first issue addressed is whether mnemonic strategies should be used *at all*. Shepherd and Gelzheiser (1987) maintained that "memorization is usually judged not to be an appropriate way to learn information that can be conceptually organized" (p. 257). It is certainly agreed that conceptually organizing and relating material to an extant knowledge base is a good way of meeting certain important educational objectives (e.g., Pressley, McDaniel, Turnure,

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Wood, & Ahmad, 1987; Pressley, Symons, McDaniel, & Snyder, 1988). One problem is that the learner must have a well-developed knowledge base to which the to-be-learned content can be related. Since LD students often have impoverished knowledge bases (e.g., Forrest-Pressley & Waller, 1984), strategies that place heavy emphasis on the extant knowledge base are often difficult for LD children to execute (e.g., Pressley, Borkowski, & O'Sullivan, 1985; Pressley, Borkowski, & Schneider, 1987; Schneider & Pressley, in press). Thus, there is motivation to develop strategies and aids for LD students that do not require much previous knowledge about to-be-learned content. The case has also been made that conceptual organization, though potentially effective in promoting comprehension of relationships within a content domain, has not always been effective in promoting recall of target information (Scruggs, Mastropieri, Levin, McLoone, Gaffney, & Prater, 1985; Veit, Scruggs, & Mastropieri, 1986). In designing instruction, it is important to remember that instructional procedures should parallel instructional objectives (Mastropieri & Scruggs, 1987).

Our position is that neither unchecked optimism or great pessimism is presently justified with respect to memory strategy instruction for LD students. There has been important progress in identifying some strategically based memory interventions (including mnemonic-keyword techniques) that enhance performance of LD students. More research is required to determine if LD populations can be taught to use complex mnemonic strategies appropriately and generally. Even if this particular goal cannot be met, there is still reason to be optimistic that important educational applications can follow from strategy research. Mnemonic strategy research has at least as much to do with how teachers should teach as it does with how learners should learn (Mastropieri & Scruggs, 1987).

Shepherd and Gelzheiser's (1987) argument that the existing literature on memory strategy instruction is not sufficient to inform classroom practice is found to be unduly pessimistic, particularly their lament that there were few studies in which "conditions of instruction are similar to those found in the classroom" (p. 258). They recommended that experiments be conducted in which (a) the conditions of instruction are comparable to classroom conditions, (b) students memorize materials that would be memorized in school, and (c) participants are required to use the information in ways that would be expected in school. Though there is certainly room for development in these areas, the case to be made is that research exists that is highly relevant to classroom instruction. In addition, it is argued that Shepherd and Gelzheiser (1987) either fail to realize or do not acknowledge that such research should come only after a good deal of other, nonclassroom research has been conducted. It should be carried out in light of analyses of students' needs for instruction and students' competencies to carry out procedures taught in the classroom. Such analyses are generated when researchers respond to the first two research questions considered here.

IMPORTANT RESEARCH QUESTIONS

Do Learning Disabled Students Use Memory Strategies Already?

There has been little programmatic research on spontaneous use of memory strategies by LD students. Only a few strategies and tasks have been substantially studied; one example is list learning as mediated by rehearsal and categorization strategies (e.g., Bauer, 1979; Torgesen, 1980). How LD students respond to other memory tasks is not understood as completely (Worden, 1983). The assumption seems to be that failure to use a simple strategy like rehearsal suggests a general failure to use strategies such as a production deficiency (Flavell, 1970) by LD students (e.g., Barclay & Hagen, 1982). Though this is a tenuous conclusion, it can be accepted since there are many important memory tasks for which few students use especially sophisticated strategies (e.g., Bereiter & Bird, 1985; Christopoulos, Rohwer, & Thomas, 1987; Griswold, Gelzheiser, & Shepherd, 1988; Mastropieri, Scruggs, & Levin, 1985; Pressley & Levin, 1977). The LD students are probably at least as production-deficient as normal students in these situations (i.e., they do not generally and appropriately use sophisticated memory strategies).

For the most part, the most sensitive diagnoses of strategy use occur in one-to-one laboratory-like situations (Flavell, 1970). A variety of approaches can be used to diagnose strategy use (see Miller, 1986, chap. 7), including reaction-time measures, verbal reports, and observations of overt behaviors (e.g., lip movements, taking notes, sorting to-be-learned pictures into categories). When strategy use is detected in the laboratory it makes sense to extend diagnosis activities into the classroom. Even though strategy use might occur, given the intensity and task focus demanded by one-to-one interaction in the controlled laboratory setting, students might not use the same strategies on the same task in the uncontrolled classroom setting. The difficulties and costs of diagnosis are much greater in the classroom than in the laboratory, though great progress is being made in devising valid diagnostic tools that are economical in terms of researcher resources (e.g., Marx, Winne, & Walsh, 1985; Peterson & Swing, 1983). For instance, students can be videotaped working on tasks and later make self-reports of strategy use as they review the videotaped record with a researcher on a one-to-one basis (simulated recall) (e.g., Peterson, Swing, Braverman, & Buss, 1982; Peterson, Swing, Stark, & Waas, 1983). In recommending classroom diagnoses of strategy use, there appears to be no research where there was a convincing and thorough assessment of LD students' use of memory strategies in classrooms. There has also been little classroom study of attending, listening, and note-taking strategies (e.g., Mastropieri & Scruggs, 1987, chap. 9) that are considered especially critical for LD students. It should be pointed out that classroom measures are not the only "ecologically valid" measures of real-world strategy use. For instance, there should be assessment of independent use of learning strategies during homework activities and study halls.

Can Learning Disabled Students Learn to Use Memory Strategies?

The best way to answer this question with respect to a particular strategy is to conduct an instructional experiment. Students are taught the strategy in question, making certain that they know what is required of them. Instruction should be provided so that the probability of successful strategy use is maximized with one-to-one instruction, like that provided in laboratory studies. The performance of students given instruction is then compared to the performance of control students who are left to their own resources to learn the same materials (and who presumably are using less efficient procedures than the strategy being taught). If strategy-instructed students fail to outperform control students in an instructional situation that favors their success (e.g., like the laboratory), it is quite likely that they would be no more successful in less supportive instructional environments such as the classroom.

There are not many memory strategies that have been studied in detail in true instructional experiments (e.g., Campbell & Stanley, 1966) with LD students. The strategies that have been considered in depth are the same as those examined in the "spontaneous use" studies (i.e., rehearsal & categorization) (Bauer, 1979; Dallago & Moely, 1980; Tarver, Hallahan, Kauffman, & Ball, 1976; Torgesen, 1977). In general, it has proven possible for LD students to carry out simple strategies when given instructions to do so. Shepherd and Gelzheiser (1987) found it disturbing that so few memory strategies have been tested to determine if LD students can carry them out effectively. They pointed out that they were aware of no evidence that LD students can execute associative mnemonic strategies. Though this assertion may be true for some specific associative strategies, it is not true for instructional research with the mnemonic keyword and pegword methods. Recent instructional experiments on these techniques have been conducted in both one-to-one and regular instructional settings. In evaluating the one-to-one instructional experiments, it must be remembered that many LD students frequently receive one-to-one instruction in their special education settings.

Mastropieri, Scruggs, and Levin (1985) taught LD adolescents the hardness levels (according to Moh's scale) of selected North American minerals using a complex keyword-pegword technique. Compared with teacher-led questioning and free study conditions, mnemonic instruction resulted in over 100% higher levels of recall. Delayed recall tests (Mastropieri, 1983) indicated that these differences were maintained over a 24-hour period. Hardness levels of minerals were chosen to represent content learned in school that has an associative structure. Despite Shepherd and Gelzheiser's (1987) argument that a task such as learning mineral hardness ratings is not an example of school learning, that task was one instructional objective for science classes in the school district where the project was undertaken. The case is fairly strong that there are many school-learning tasks that involve learning of associations (Pressley, Levin, & Delaney, 1982). These tasks include chemical elements and their properties, basic social studies content, and weekly vocabulary taught in English and foreign language classes. Because it is not possible to study all contents with associative structural characteristics, most experiments select only one or two.

Several experiments followed the original Mastropieri, Scruggs, and Levin (1985) study, including the mnemonic teaching of multiple attributes (color, hardness, use) of minerals (Scruggs, Mastropieri, Levin, & Gaffney, 1985), mnemonic teaching of dichotomized attributes using symbolic encodings (soft/hard, light/dark in color, home/industrial use) (Mastropieri, Scruggs, Levin & McLoone, 1985), and a two-experiment comparison of both procedures with a "visual-spatial" learning condition (Scruggs, Mastropieri, Levin, McLoone, Gaffney, & Prater, 1985). These extensions of the hardness-level experiment provided additional support for the efficacy of these techniques and further extended the instructional utility of the keyword and pegword methods. In three further experiments, mnemonic pictures and strategy instructions were embedded in instructional reading materials. The LD students who independently read these materials significantly outperformed control students who read the same passages, including representative pictures (Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1987; Mastropieri, Scruggs, & Levin, 1987). In another investigation, Mastropieri, Scruggs, Levin, Gaffney, and McLoone (1985) taught LD students to use their own interactive images in learning the definitions of novel English vocabulary words. The results of all these experiments provided conclusive evidence that LD students can be taught to execute mnemonic strategies and experience learning gains when they do so.

Can Learning Disabled Students Learn to Use Memory Strategies Both Generally and Appropriately?

Suppose that LD students can be taught to execute a strategy successfully. What follows is whether these students can generalize the procedure to a new task that can be mediated using the strategy in question. Gelzheiser (1984) examined whether 12- to 14-year-old LD students would transfer a simple sorting-and-categorizing strategy from list learning to prose learning. LD subjects were taught to sort and to categorize lists of pictures, words, and two-word phrases in order to learn the lists for later recall. This training was successful. The prose task involved presentation of a well-structured passage consisting of four paragraphs, each explicitly subtitled. Each paragraph was composed of an initial topic sentence followed by five other sentences. After hearing and reading the passage, subjects were provided 28 important facts from the passage, each on a separate card. The subjects were told they could have 10 minutes to memorize the facts. They were told they could do anything they wanted to remember the facts and could select four cards to use as "notes" at recall. Though the results were complicated, there was convincing evidence of strategy transfer. The trained students sorted the passage facts into appropriate categories during study, with effects both on clustering during recall and level of recall.

Though Gelzheiser's (1984) study should be considered a successful demonstration of transfer by LD students, Shepherd and Gelzheiser's (1987) conclusion about this study appears overstated. They argued that "Most learning disabled children can learn to use and transfer a strategy in such a way that recall improves. Three hours of instruction is sufficient to teach them to use and transfer a strategy" (p. 254). First, this claim is based on transfer of one list-learning strategy to a prose task designed to look much like list learning (e.g., individual facts from the passage placed on cards). Second, the prose task occurred immediately following a picture list-learning task, so that strategy use on the picture list could have influenced sorting on the prose task. In short, more work is required before it can be concluded that even sorting and categorization strategies are broadly transferred by LD students, let alone memory strategies in general. For example, McLoone, Scruggs, Mastropieri, and Zucker (1986) trained LD students to transfer a mnemonic keyword strategy from an English vocabulary list to a list of Italian vocabulary words. Performance on the Italian vocabulary task by students transferring the keyword strategy far exceeded that of students trained to use a rehearsal strategy. On the basis of this single limited investigation, however, no general claims regarding the independent transfer of strategies were made.

Rather than conducting studies to determine whether LD students "spontaneously" generalize strategies, most researchers simply have assumed that LD students will not transfer strategies broadly and appropriately. This belief follows in part from the many transfer failures observed when normal children (and even highly able adults) were taught strategies (Borkowski, Carr, & Pressley, 1987; Brown, Bransford, Ferrara, & Campione, 1983; Gick, 1986; Scruggs, Mastropieri, Jorgensen, & Monson, 1986). Thus, LD researchers have focused on designing instruction to maximize generalization (e.g., Deshler, Schumaker, & Lenz, 1984; Ellis, Lenz, & Sabornie, 1987a, b; Mastropieri & Scruggs, 1987). Deshler and his colleagues at the *Institute for Research in Learning Disabilities* at the University of Kansas have developed a complete instructional package designed to encourage strategy transfer. Strategies are thoroughly described and modeled by teachers for students. Students verbally rehearse the steps in the strategy until they have mastered them. Students begin to use the strategy with teacher-led demonstrations giving way to guided practice. During strategy practice and feedback phases, students first practice with fairly simple materials, and then with grade-appropriate content. The types of results that can be expected and the situations to which the strategy can be applied are explained. Multiple exemplars are used at every phase of instruction. Students are coached about how to use the strategies in their various classes and are required to try to apply them to actual class assignments. Many reminders are provided about where strategies can be used. There is a great deal of consistent practice in applying the strategy to class assignments, and explicit efforts to make students aware of the contexts where a strategy can be applied. Students are taught to prompt themselves with self-talk about use of strategies and to be alert to cues that suggest use of a particular strategy in a setting. Sometimes students are provided cue cards that contain summaries of strategies that have been learned, with these cards used as aids to generalization. In general, evidence is accumulating that such a regimen leads to generalization of a variety of strategies. Nonetheless, when such training is not successful, there are still cognitively based alternatives that may benefit LD students. These alternatives involve the adaptation of classroom instruction to include effective learning strategies.

Can Classroom Materials and Instructional Procedures by Modified to Provide the Advantages of Strategy Instruction?

Even if it proves impossible to instruct students to execute a particular strategy (or use it generally and appropriately if it can be executed), there are still interventions that can be devised to improve learning. Given that acquisition of content knowledge is a high priority in school (a point of view acknowledged by Shepherd and Gelzheiser, 1987), these interventions deserve serious study and consideration by the special education community (a point of view challenged by Shepherd and Gelzheiser). Teachers can often modify materials to be learned to provide students with mediators like the ones they might themselves produce if they could execute an appropriate strategy (e.g., Gagne' & Bell, 1981; Mastropieri & Scruggs, 1987; Pressley, 1983). Keyword mnemonics research in particular earns high marks in this regard.

Associative Memory and School Learning. Despite Shepherd and Gelzheiser's (1987) opinion to the contrary, students are often required to memorize material, with important evaluations of their competency based on whether memorizing is successful (e.g., Deshler & Schumaker, 1988). There have been many demonstrations that keyword-mnemonically structured materials facilitate LD students' learning of otherwise difficult-to-acquire content (e.g., Mastropieri & Scruggs, 1988; Nagel, Schumaker, & Deshler, 1986; Scruggs & Mastropieri, 1988). To date, many different content areas have been adapted to keyword and pegword mnemonic materials and instructional procedures with LD students, including English vocabulary (Berry, 1986; Condus, Marshall, & Miller, 1986; Mastropieri, Scruggs, Levin, Gaffney, & McLoone, 1985; McLoone et al., 1986; Taylor, 1981), Italian vocabulary (McLoone et al., 1986), scientific terms composed of Greek root words (Viet et al., 1986), attributes of North American minerals (e.g., Mastropieri, 1983; Scruggs, Mastropieri, Levin, & Gaffney, 1985), attributes of prehistoric reptiles (Veit et al., 1986), reasons for dinosaur extinction (Mastropieri et al., 1987), U.S. history (Scruggs & Mastropieri, in press), and Indiana history (Mastropieri & Scruggs, 1989a).

The best guess is that mnemonic materials could be devised for any content that has some associative structure. For instance, Nagel et al. (1986) covered in detail the use of first-letter mnemonic methods to remember lists of items. Suppose that as part of a science lesson, a student is required to learn five uses of peanuts, including making of *s*andwich spread, *s*oap, *o*il, *e*xplosives, and *p*lastics. Recoding the first letter of the products into the word PESOS can facilitate learning and later recall of the list. According to Mastropieri and Scruggs (1987) such first-letter mnemonics are most likely to be remembered when (a) responses are highly familiar, such that the recall is likely to trigger recall of the entire word, and (b) the composite word is linked mnemonically to the stimulus (i.e., in the case, an interactive picture or image of someone paying for peanuts with *pesos*). Difficult-to-learn sequences of arithmetic operations can also be encoded using mnemonic procedures (Higbee & Kunihira, 1985; Levin, 1985; Pressley, 1985). Young children can be taught letter-sound associations (Ehri, Deffner, & Wilce, 1984), and mildly handicapped children have been taught number-symbol associations for remembering number sequences (Laufenberg & Scruggs, 1986).

Many of Shepherd and Gelzheiser's (1987) reservations about mnemonically structured materials are puzzling in light of extensive data about the effects produced by these aids. Shepherd and Gelzheiser argued that it would be unlikely that students learning vocabulary via mnemonic materials would be able to use the newly learned words when speaking or writing. This claim is blind to demonstrations that vocabulary acquired vis-à-vis mnemonic procedures can be used and comprehended in context as effectively as vocabulary learned using other procedures (Pressley, Levin, & Miller, 1981; Mastropieri, Scruggs, & Fulk, in press; Veit et al., 1986). Their argument that use of the keyword method is restricted to learning short, imprecise meanings similarly ignores demonstrations in which more complex definitions have been learned using this method (Mastropieri, Scruggs, & Fulk, in press; Pressley et al., 1982; Veit et al., 1986).

Reconstructive elaborations. Research has consistently demonstrated that the "apparent" limitation of mnemonic instruction crumbles when examined in well-designed experiments. For instance, it may seem that the keyword method is most appropriate when stimulus information is unfamiliar (information about unfamiliar people, places, or "things" such as minerals). Nevertheless, it has proven possible to extend the method to facilitate associations of familiar, concrete as well as familiar, abstract information. In order to incorporate all relevant associative information in a textbook chapter into mnemonic representations, Scruggs and Mastropieri (in press) developed a system of "reconstructive elaborations" and applied it to relevant textbook information on U.S. history (see also Mastropieri & Scruggs, 1989b). Such elaborations were devised with respect to the level of familiarity and concreteness of the associative information. Relationships between concrete, familiar associates (e.g., that conditions in World War I trenches were unhealthy) can be depicted via mimetic or representational elaborative pictures. In the present instance, unhealthy soldiers are pictured in trenches. Relationships between familiar but more abstract information (e.g., the U.S. policy of neutrality at the start of World War I) can be depicted via symbolic encodings of the abstract information, rendering such information more concrete. In this case, a picture of Uncle Sam, symbolizing U.S. policy, can be shown not joining in symbolized hostilities in Europe. Keyword mnemonics are used when information is unfamiliar and therefore not concrete to the learner; for example, the fact that Eddie Rickenbacker was a flying ace who shot down enemy airplanes. Using the keyword method, a *linebacker* (keyword for *Rickenbacker)* can be shown in an airplane shooting down enemy planes. In order to learn relevant serial list information (e.g., that Turkey, Austria-Hungary, and Germany were members of the Central Powers), a combination of keyword and first-letter strategy can be employed. In this case, a picture of people playing *tag* in *Central Park.* Central Park is a keyword for Central Powers, and the game of tag represents a first-letter strategy for the countries of *T*urkey, *A*ustria-Hungary, and *G*ermany. In an experimental evaluation, Scruggs and Mastropieri (in press) observed that LD students taught with such reconstructive elaborations outperformed students taught with more traditional procedures by a margin of nearly two-to-one. This finding held on immediate as well as 3- to 4-day delayed recall. If such mnemonically elaborated text were to become a staple of effective special or mainstream education, the necessity of training LD students to generalize elaborative strategies would be reduced.

Can Memory Strategies Be Taught to Learning Disabled Children in Classrooms?

Assuming that instruction can be devised so that LD children can use a strategy, and possibly generalize it, is it possible to teach the strategy in the classroom? Alternately, if it is not possible to teach the strategy but is possible to modify materials to provide strategy benefits, can the materials be used profitably in the classroom? It makes sense to address these questions only after it has been determined in nonclassroom settings that students can execute the strategies or benefit from the provision of materials containing mediators. It is much easier and cheaper to manipulate strategies and materials in the laboratory than in the classroom. The possibility of control in the laboratory presents much more analytical flexibility than in the classroom.

For instance, this laboratory-to-classroom research sequence was followed by Pressley, Levin, and their associates with respect to instruction of grade-school children in the use of the keyword method. After establishing that grade 5 and grade 6 normal children could carry out the keyword strategy when presented vocabulary in a one-to-one setting (e.g., Pressley & Levin, 1978), Levin, Pressley, McCormick, Miller, and Shriberg (1979) demonstrated that same-age children could be taught to use the method in the classroom. Likewise, several investigations have determined that LD students can be taught to carry out keyword strategies in their own classrooms when instructed in their regular instructional groupings. Mastropieri, Scruggs, and Levin (1986) replicated the laboratory findings of Mastropieri, Scruggs, and Levin (1985) in classroom settings. Veit et al. (1986) and Mastropieri and Scruggs (1988) demonstrated the effectiveness of mnemonic strategy instruction when students were taught in their regular instructional groups in the classroom, over several different lessons using different mnemonic procedures. Additionally, LD teachers have taught classroom vocabulary successfully with the keyword method over a 5-week period. Students instructed mnemonically learned substantially more vocabulary than students instructed by a variety of control procedures and maintained this advantage over a 10-week delayed recall interval (Condus, Marshall, & Miller, 1986).

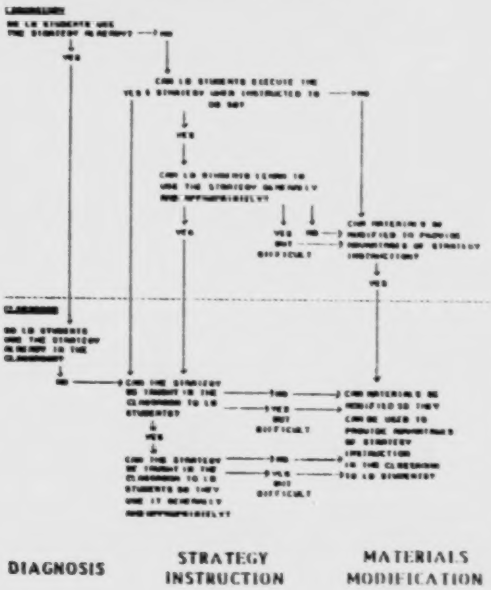
DISCUSSION

There is agreement with Shepherd and Gelzheiser's (1987) conclusion that more research is needed before final statements can be offered about whether memory strategies can be taught profitably in classrooms serving LD students. How that research could proceed most rationally and what should be expected from memory strategy research are summarized in Figure 1. It is believed that research on memory strategy instruction should be conducted first in the laboratory, then in the classroom.

A first step should be diagnosis of current performance and strategy use. Diagnosis is most sensitive when students are tested one-on-one in a controlled setting with controlled materials. If LD students show appropriate strategy use in this setting, complementary diagnoses should be carried out in the classroom. Once information is gained about LD students' uninstructed use of strategies, researchers are in a position to make informed decisions about how to conduct strategy instructional research.

When LD students do not show strategy use during individual testing, additional laboratory research is appropriate, with the first issue being whether LD students can execute the strategy of interest when so instructed. If the answer is affirmative, it makes sense to study whether LD students can be taught to use the procedure in the classroom and to determine whether they can learn to use the strategy generally and appropriately. The ultimate instructional research goal is to determine whether LD students can learn to use the strategy efficiently in classroom settings. It must be stressed that this is an important question, one that can and should be addressed only after other issues have been resolved, most importantly that LD students can carry out the procedure when it is taught in the classroom.

FIGURE 1: Directions for memory strategy instructional research



If it becomes apparent that LD students either cannot learn how to execute or to generalize a strategy or can do so only with great difficulty, this should not be cause for despair. There is still the possibility that materials modifications might produce the benefits that would have followed successful strategy execution and appropriate deployment. Of course, there is a long history of materials modifications that attempt to "make up for" processing that students either cannot or will not make. Materials modifications that are in current use include provision of adjunct questions in text (e.g., Anderson & Biddle, 1985) and the addition of representational illustrations to text (e.g., Levie, 1987; Levie & Lenz, 1982; Levin, 1976). To-be-learned materials can be reorganized and "signals" can be added to make clear content deserving special attention (e.g., Mayer, 1987, chap. 7). Shepherd and Gelzheiser's (1987) derogation of materials modification is not warranted, given previous educational research and practice.

A frank admission is that, outside of mnemonics research, there is little research with LD students that follows the "rational" course outlined in Figure 1. Gelzheiser's (1984) work on sorting and categorizing, to a certain extent, did do so. She knew from previous studies that LD students used categorization strategies less often than same-age normal children (e.g., Torgesen, 1977; Torgesen, Murphy, & Ivey, 1979). She also knew from previous research that LD adolescents could carry out sorting and categorization strategies profitably (e.g., Torgesen, 1977). Her own study was aimed at determining whether sorting and categorization training would transfer, when training occurred in a controlled, laboratory-like setting. Evidence of transfer was found, albeit to a somewhat artificial prose-learning task. A possible interpretation of this situation is that additional laboratory studies of transfer could be worthwhile and might facilitate eventual design of classroom instruction that transfers. Alternately, that categorization can be carried out at all by LD students opens the question of whether strategy execution could be taught in the classroom. Studies could be conducted that address

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these issues, with studies of transfer deferred until this work is completed.

The work on elaboration strategies has also attended to the strategies already used by LD students and whether they can be taught to execute and transfer such strategies in the laboratory (e.g., McLoone et al., 1986). Because mnemonics researchers believed that LD students would not use complicated elaborative procedures like the keyword method without instruction (e.g., Scruggs, Mastropieri, & Levin, 1987), researchers interested in elaboration have concentrated on providing elaborative mediators for LD students. These studies have been conducted in both the laboratory (e.g., Mastropieri, Scruggs, & Levin, 1985) and the classroom (e.g., Mastropieri, Scruggs, & Levin, 1986). Recent successes in teaching LD students to construct their own elaborative mediators suggested that it might be appropriate to move "backwards" in the flowchart (Figure 1), with additional studies of strategy instruction and generalization. The best guess is that, unlike simple strategies like rehearsal and clustering, such instruction is often going to prove difficult (and sometimes impossible). Hence, there will probably be enough motivation to continue research and development of modified materials. Mnemonics researchers, like all others who are interested in improving the memory capabilities of LD students, have much more work to do.

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Appendix O

Scruggs, T.E., & Mastropieri, M.A. (1989a). Mnemonic instruction of learning disabled students: A field-based evaluation. Learning Disability Quarterly, 12, 119-125.

MNEMONIC INSTRUCTION OF LD STUDENTS: A FIELD-BASED EVALUATION

Thomas E. Scruggs and Margo A. Mastropieri

Abstract. **A sizeable number of research studies have demonstrated the potential of mnemonic instruction with learning disabled (LD) students. However, reports of actual classroom applications of this type of instruction are lacking. In the present investigation, three classrooms of LD junior-high-school-age students were taught U.S. history content over an 8-week period, in which mnemonic and nonmnemonic materials were alternated. Evaluation of chapter test scores indicated that students learned significantly (and substantially) more information when instructed mnemonically, and that they were assigned higher grades for chapters which had been instructed mnemonically. Furthermore, teacher ratings indicated that mnemonic materials were significantly more appropriate for the needs of LD students than traditional textbook-based materials. Implications for future research and practice are addressed.**

Mnemonic strategy instruction has recently been recommended as an effective method for addressing the serious and persistent learning difficulties of students characterized as learning disabled (LD) (e.g., Mastropieri, 1988; Pressley, Scruggs, & Mastropieri, in press; Scruggs, Mastropieri, & Levin, 1987). Mnemonic strategies, such as the keyword method, rely upon the acoustic properties of unfamiliar words and the learner's own visual imagery to establish a powerful connection between stimulus and response information. For example, to teach that *alliance* means an agreement not to fight, and to protect other members, a keyword is first constructed for the target word. In this case, "lions" is a good keyword, because it is acoustically similar to alliance and is easy to picture. Learners can be shown (or be asked to generate) a picture of several lions forming an alliance (e.g., agreeing not to fight and to protect each other). When asked the meaning of *alliance*, then, the learner is able to (a) think of the keyword, *lions*, (b) think back to the picture of the lions; and (c) remember that they are making an agreement not to fight and to protect each other, thereby retrieving the answer. Scruggs, Mastropieri, Levin, and Gaffney (1985) referred to these attributes—"recoding," "relating," and "retrieving"—as the "three Rs" of mnemonic instruction.

Since memory for acoustic similarities and memory for pictures appear to be less developmentally sensitive than other types of memory (e.g., Torgesen & Kail, 1980), students who are less developmentally advanced would be expected to benefit from mnemonic techniques such as the keyword method. In fact, LD students have benefited dramatically from such strategies, often outperforming their peers instructed by more traditional methods by margins of as much as two-to-one on tasks designed to assess the effectiveness of the strategies (Mastropieri, Scruggs, & Levin, 1985).

Mastropieri (1983) investigated the effectiveness of a combined keyword-pegword technique for learning the hardness levels of North American minerals. In this study, the keyword method (e.g., sulfur = sofa) was combined with a rhyming pegword method (two = shoe) to provide an in-

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teractive picture of mineral hardness levels (e.g., sulfur = 2, a picture of a *shoe* on a *sofa*). Mnemonically instructed ninth-grade LD students quickly learned 75% of the target information, whereas subjects in a free-study condition learned only 36%; those in a drill-and-practice condition learned 28%. The mnemonic advantage was observed to maintain over a 24-hour delay interval. Furthermore, a replication study showed the superiority of mnemonic vs. drill-and-practice "direct instruction" techniques when mineral hardness levels were taught to LD students in their regular instructional groups, with relative mean scores of 80% vs. 50%, respectively (Mastropieri, Scruggs, & Levin, 1986).

In further experiments, mnemonically instructed LD students outperformed pupils taught by other methods in learning multiple specific attributes of minerals, such as color, hardness, and use (Scruggs, Mastropieri, Levin, & Gaffney, 1985; Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1987), as well as when these attributes were dichotomized (Mastropieri, Scruggs, McLoone, & Levin, 1987; Scruggs, Mastropieri, Levin, McLoone, Gaffney, & Prater, 1985). The same results held true when students learned the information independently from prose (Mastropieri, Scruggs, & Levin, 1987a; Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1987).

Mnemonic instruction for vocabulary learning has also been investigated. Mastropieri, Scruggs, Levin, Gaffney, and McLoone (1985) taught unfamiliar English vocabulary words (e.g., *ranid*, meaning *frog*) to LD students via either mnemonic instruction or rehearsal-based drill-and-practice direct-instruction techniques. After instruction, mnemonically instructed students recalled 80% of the definitions of the vocabulary words, compared to their peers who learned only 31% after direct instruction. In a second experiment, students instructed to generate their own interactive images also outperformed direct-instruction condition students, with correct scores of 69% and 47%, respectively.

In an additional vocabulary learning study (McLoone, Scruggs, Mastropieri, & Zucker, 1986), LD students, who were trained to transfer the keyword method between English and Italian vocabulary words, likewise outperformed students in rehearsal-based control conditions. Similarly, Condus, Marshall, and Miller (1986) demonstrated that the keyword method was superior to a variety of control conditions for teaching vocabulary in classrooms over a 5-week period. Th mnemonic advantage was observed over a 10 week delayed recall period. Most recentl Mastropieri, Scruggs, and Fulk (in press) used th keyword method to teach abstract as well as concrete vocabulary words to LD students. Their findings showed that mnemonically instructe students outperformed context-based direct instruction control students by a wide margin o both types of words, on comprehension as we as recall tests.

Veit, Scruggs, and Mastropieri (1986) evaluate the effectiveness of teaching several mnemoni systems over several days of instruction to L students. Over three days of instruction, Veit al. (1986) incorporated keyword mnemonics, peg word mnemonics, as well as symbolic illustratio and symbolic colors to teach a variety of inform tion about prehistoric reptiles. Mnemonically in structed LD students did not suffer interferen problems with the introduction of multip mnemonic systems, and they continued to outper form LD students in direct-instruction condition not only over the three days of instruction but als on a cumulative delayed-recall test.

Although mnemonic instruction has resulted i a consistent level of success with LD students, th adaptability of mnemonic strategies to an existin content-area curriculum has only recently been in vestigated. Scruggs and Mastropieri (in press adapted a chapter of U.S. history dealing wit World War I to mnemonic instruction. Keywor mnemonics are most appropriate in situatio where stimulus information is unfamiliar to th learner (Mastropieri, Scruggs, & Levin, 198 Therefore, elaborations were also developed to ac commodate information which was familiar bu abstract (e.g., U.S. policy), and information whi was familiar and concrete (e.g., submarines). F this mnemonic model, termed *reconstructi elaborations*, keywords provided *acousti* reconstructions of unfamiliar information, symboli pictures of abstract concepts provided *symboli* reconstructions, while descriptive pictures of concrete information provided *mimetic* reconstruc tions. These reconstructed stimulus items wer then pictured as interacting with response infor mation in pictures similar to those of previou keyword investigations. In addition, a first-lette strategy, linked to keywords, was used to facilitat retrieval of serial list information (i.e., the com

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tries associated with each prewar alliance).

Scruggs and Mastropieri (in press) taught LD students relevant information about World War I using either reconstructive elaborations or experimenter-led drill and practice with conventional representative pictures. Students who were taught mnemonically outperformed control-condition subjects by a wide margin. In addition, they maintained this advantage over a 3- to 4-day delayed-recall interval.

The Scruggs and Mastropieri (in press) investigation yielded important information regarding the applicability of mnemonic techniques to existing content-area curriculum and the powerful learning effects of such applications. With few exceptions, however, mnemonic strategy experiments (a) have been relatively short in duration, (b) have typically involved only a single training session, (c) have utilized experimental lists of information, rather than actual curriculum, and (d) have employed experimenters, rather than regularly assigned teachers to deliver instruction. Exceptions include two investigations: (a) Veit et al. (1985), who evaluated the effects of several days of mnemonic instruction, but employed experimental tasks and experimenter-led instruction; and (b) Condus et al. (1986), who employed teacher-led extended instruction, but taught only short vocabulary lists three times a week, outside the context of a specific content area.

The laboratory-type experiments described above are important for systematically examining the potential of various mnemonic techniques (Pressley, Scruggs, & Mastropieri, in press); however, it is also important to evaluate actual curriculum-based classroom applications of these strategies in content-area instruction over extended time periods. Although some experimental control is lost in such field-based evaluations, the actual classroom potential of these strategies must be assessed.

In the present investigation, we adapted U.S. history content to mnemonic instruction, corresponding to chapters 24 and 26 of an assigned U.S. history textbook, *Land of Liberty* (Rawls & Weeks, 1985). To avoid problems associated with randomly assigning students within existing school structures, and to avoid interpretive difficulties stemming from classroom effect and subject attrition, we employed a within-subjects design across classrooms. Each student was instructed as follows: one chapter of mnemonic instruction; one chapter of traditional, textbook-based instruction; another chapter of mnemonic instruction; and a final chapter of traditional instruction. This design allowed for a systematic evaluation of classroom mnemonic instruction.

METHOD

Subjects

Subjects were 26 students attending three history classes for students with learning disabilities in an inner-city, midwestern junior-high school. Due to student absenses throughout the study, the final analysis involved 20 subjects. (Descriptive information is provided on this sample.) Forty percent of the students were black, 60% were Caucasian; 90% of the students were male. The mean age was 13 years, 8 months ($SD = 2$ years, 6 months), and subjects included seventh and eighth graders.

All students had been classified as learning disabled on the basis of initial teacher referral, evaluation by special education personnel and a school psychologist, and a multidisciplinary team meeting in which the team agreed that a given student met state and federal standards for classification as LD, that is, a significant discrepancy between ability and achievement not explained by sensory, emotional, environmental, or intellectual factors. Exact intelligence scores were unavailable for this investigation, but all were reported to fall in the "average" or "low average" range. The sample's average reading-grade equivalent based on the *Wide Range Achievement Test*, as reported by the classroom teacher, was 4.96 ($SD = 1.8$); average math-grade equivalent was 5.84 ($SD = 1.4$). Students had been enrolled in special education programs for an average of 5.85 years ($SD = 1.2$). At the time of this investigation, they were spending at least five periods a day in special education classes. All students were described by the teacher as deficient in study skills.

The teacher of the three classes had been teaching for 21 years, held a Master's degree plus 15 graduate credit hours, and was certified to teach learning disabled, mildly mentally handicapped, and emotionally disturbed students from kindergarten through twelfth grade.

Materials

Mnemonic materials. Mnemonic materials were adapted from a regularly assigned U.S. history textbook, Chapter 24, *World War I*, and Chapter 26, *The Great Depression*. An outline for

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each chapter was developed. Outlines and illustrations were copied on transparencies for use with overhead projectors. Twenty to 30 mnemonic pictures were used for each chapter. In addition, teacher scripts were developed to accompany the information presented in each mnemonic picture. The scripts included important relevant historical information as well as an explicit description of the mnemonic picture. In addition, scripts contained a description of the chapter outlines, description of the information to be learned, information about strategy use, and review-and-practice pages. An example from the scripted lessons is given below:

> *The sinking of the Lusitania was one thing that angered Americans against the Germans and the Central Powers. The second thing that angered Americans was the Zimmerman note. In 1915, the English intercepted a note from the German foreign minister, Arthur Zimmerman, to the government of Mexico. The note proposed that Mexico join Germany in war against the United States. When the war was over, the note said, Mexico could regain Texas, New Mexico, and Arizona. What was in the Zimmerman note? Good. It was from the Germans and asked Mexico to fight the United States [show "Zimmerman" overhead].*
>
> *To remember who Arthur Zimmerman was, think of the keyword for Zimmerman: Swimmer. What is the keyword for Zimmerman? To remember who Zimmerman was, think of this picture of a swimmer swimming while carrying a note to Mexico. (Zimmerman, a German foreign minister, sent a note to Mexico.) The note asked the Mexicans to fight the U.S. Who was Arthur Zimmerman? And how can you remember who Zimmerman was? Good. Remember, Zimmerman wasn't really a swimmer, it's just the keyword we use to remember that he sent a note to Mexico.*

Student booklets, containing the first paragraph of the teacher script and the mnemonic picture, were developed to accompany each chapter.

Traditional materials. Instructional materials were developed which paralleled the mnemonic materials, that is, textual information which was identical to the mnemonic materials, with the exclusion of mnemonic pictures and mnemonic strategy information. These materials covered information presented in Chapter 25, *The Roaring Twenties*, and Chapter 27, *Seeds of Conflict*. The selected chapters paralleled the mnemonic chapters in content and difficulty, and, like the mnemonic materials, included one wartime and one peacetime chapter.

Both conditions. The regular classroom materials were also available to students in both conditions. These included textbooks, student worksheets, and notes.

Procedure

For all instruction, the teacher was asked to use the model of effective instruction (Mastropieri & Scruggs, 1987a). This included (a) daily review, (b) statement of instructional objective, (c) teacher presentation of new material, (d) guided practice, (e) independent practice, and (f) formative evaluation. Trained project staff provided the teacher with information on how to implement instructional procedures. A videotaped model of mnemonic instruction was also made available to the teacher. The teacher was asked to provide the best possible instruction throughout the unit, but to present mnemonic strategy information for the mnemonic chapters only.

The teacher implemented the four chapters over a period of 8 weeks. Each of the three classes met every day for 50 minutes, and covered each chapter in 2 weeks. Mnemonic and traditional instructional chapters were alternated throughout the unit.

Dependent Measures

At the end of each 2-week chapter, a 20- to 30-item multiple-choice test was given on chapter content. The tests addressed content covered in the classroom presentations and activities, and identified by the publisher as important by its emphasis in the chapter, or appearance on published worksheets and practice activities. Tests were thorough and, according to the teacher, more difficult than the tests typically given during the school year.

At the end of the 8-week unit, the teacher was asked to turn over grades recorded for each student under traditional and mnemonic instruction. These grades reflected a qualitative evaluation of student performance on tests, quizzes, worksheets, and class participation. Also, the teacher was asked to fill out a *Behavioral Intervention Rating Scale* (BIRS; Von Brock & Elliott, 1987) for each student regarding her perception of the appropriateness of traditional and mnemonic instruction for each student's specific learning needs. The teacher was asked to fill out the survey with respect to students' academic behavior.

RESULTS

Chapter test scores were combined across the two mnemonic and two traditionally taught chapters to obtain one overall mnemonic and one overall traditional test score. Due to absenses and suspensions, all students were not available to take all tests, but for 20 of the 26 students, at least one mnemonic and one traditional test score were available. Overall, students scored an average of 62.4% (SD = 15.9%) correct under mnemonic instruction, compared to 46.8% (SD = 15.7%) correct under traditional instruction. These means were reliably different according to a t-test for correlated samples, $t(19) = 5.00$, $p = .000$.

Students' assigned grades for mnemonic and traditional chapters of instruction were quantified by assigning them to a 12-point scale (F = 0 and A + = 12). Overall, students earned an average grade of "B" (8.0) under mnemonic instruction, and an average grade of "D + " (3.0) under traditional instruction. According to the teacher, the grades reported for traditional instruction were typical of chapter grades earned throughout the school year. These differences between grades were statistically meaningful according to a Wilcoxon matched-pairs signed-ranks test (Siegel, 1956), $z = 3.82$, $p = .000$.

Finally, the teacher filled out the BIRS, evaluating the appropriateness of each type of instructional material for each student. Average reliability of the scale was computed at .73 by means of Cronbach's alpha statistic. Mnemonic materials were rated as significantly more appropriate for content-area instruction of LD students, according to a Wilcoxon matched-pairs signed-ranks test applied to summed BIRS scores, $z = 4.01$, $p = .000$. The teacher also reported that students (a) enjoyed using the mnemonic materials, (b) were more motivated during mnemonic instruction, and (c) engaged in substantially more class discussion during mnemonic instruction.

DISCUSSION

The results of this field-based evaluation suggest that mnemonic materials can substantially improve LD students' content area learning. Positive gains were seen in test scores as well as overall assigned grades after mnemonic instruction. Additionally, some preliminary information was gathered concerning teacher acceptance of mnemonic teaching materials, and the degree to which they may be regarded as appropriate for instruction of LD students.

The results of this evaluation parallel previous positive results obtained in more tightly controlled experimental investigations of mnemonic instruction (Mastropieri, Scruggs, & Levin, 1987b; Scruggs, Mastropieri, & Levin, 1987). In most prior investigations (e.g., Mastropieri, Scruggs, Levin, Gaffney, & McLoone, 1985), experimenter dialogue has been completely controlled, and experimental activities have been timed to the second to provide scientifically rigorous evaluations of the potential of mnemonic instruction. In all known cases, LD students instructed mnemonically have outperformed, by a wide margin, students taught by other methods. Nevertheless, little was known about the effects of actual classroom application of mnemonic instruction. In the present investigation, the strategies were tested in a "real world" environment, which included tardiness, absenses, suspensions, announcements, assemblies, visits to the nurse, and field trips. Mnemonic instruction was observed to result in strong, positive effects in learning similar to those evidenced in laboratory-based investigations.

Unlike the previous laboratory research, however, the present design embodied some interpretive difficulties. First, the within-subjects design did not allow students to study identical chapters under mnemonic and traditional conditions. Therefore, differences in chapter difficulty may have contributed to the outcomes. To circumvent this possibility, chapters were equated as much as possible, prior to implementation, for content (one peacetime and one wartime chapter for each condition) and difficulty of target information (similar numbers of items on similar types of content). Further, instructional materials paralleled a widely used history text that had been divided into chapters of comparable length and difficulty.

Second, "novelty effects" may have influenced the outcomes. Nevertheless, the present results were obtained over an 8-week period, and the teacher reported no inhibition of effects over time. Additionally, Condus et al. (1986) reported consistently high effects in mnemonic instruction of vocabulary words over a 5-week period and a 10-week delayed recall interval. It seems unlikely, therefore, that novelty effects alone accounted for observed performance differences.

Unlike skills areas like reading and math, infor-

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mation covered in content-area instruction does not necessarily build upon itself, but may be completely different from week to week. Therefore, it poses special problems for LD students, who commonly exhibit persistent memory problems (Baker, Ceci, & Herrmann, 1987; Swanson, 1987), as they may find learning such content frustrating and unrewarding. Furthermore, deficits in basic skills such as reading and writing may further inhibit LD students from being able to apply the same note-taking and studying skills as their nondisabled peers. It is not surprising, then, that teachers have identified failure to learn and remember content-area information as one of the most important threats to mainstreaming in the secondary and middle schools (Schumaker, Deshler, Alley, & Warner, 1983). If learning disabled students are to successfully acquire content information, it is important that they use effective learning strategies to compensate for deficits in memory, reading, and study skills. Mnemonic strategies such as those employed in the present study could be very useful.

Further research is needed to replicate and extend the results of this field evaluation. In fact, efforts are currently being undertaken along these lines (Mastropieri & Scruggs, 1987b). Nevertheless, results of this and previous research studies suggest that mnemonic instruction has the potential to become an important component of special education for LD students.

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Appendix P

Scruggs, T.E., & Mastropieri, M.A. (1989b). Reconstructive elaborations: A model for content area learning. American Educational Research Journal, 26, 311-327.

American Educational Research Journal
Summer 1989, Vol. 26, No. 2, pp. 311–327

Reconstructive Elaborations: A Model for Content Area Learning

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Past research has documented the effectiveness of various elaborative techniques, such as the keyword method, in facilitating the initial acquisition and retention of isolated facts. However, little research exists in which different elaborative techniques have been incorporated within a comprehensive model for teaching all relevant information within a specific curricular domain. In the present investigation, a system of reconstructive elaborations was developed to adapt elaborative systems to different levels of concreteness of information as well as different levels of meaningfulness (or familiarity) to the learner. Such elaborations were developed for textbook information on World War I. This information was then taught individually to 30 mildly handicapped adolescents, who had been assigned at random to experimental or control conditions. Students in the experimental condition outperformed students in the control condition by a factor of nearly 2:1 on an immediate production test, and maintained a statistically significant advantage over a 3–4 day delay interval on an identification test. Implications for content area instruction of difficult-to-teach students are provided.

Researchers interested in verbal learning have, over the past several decades, developed a substantial body of empirical data regarding the means by which verbal associations are effectively acquired. The importance of *meaningfulness* and *concreteness* in the acquisition of such information has been well documented historically (e.g., Glaze, 1928; Paivio & Yuille, 1966; Underwood & Schulz, 1960). Similarly, the importance of *elaborations* of the stimulus-response association has been well documented (e.g., Jensen & Rohwer, 1963; Rohwer, 1968; Scruggs & Mastropieri, 1985; Taylor & Turnure, 1979). This paper is concerned with the interaction of these three variables and how these variables might be incorporated within a comprehensive model of content area learning.

Meaningfulness has been characterized as a function of the frequency of

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associations that can be elicited by a subject from a given stimulus (Underwood & Schulz, 1960). Underwood and Schulz described *familiarity* as the most "natural" synonym of meaningfulness. Meaningful information consistently has been found to be more memorable than less meaningful information (Underwood & Schulz; Underwood, 1983).

Concreteness has been characterized as the degree to which a particular stimulus can elicit a specific representational picture or image (Paivio, 1971). Such, a distinction, however, presumes that the to-be-learned information is meaningful (familiar) to the learner. If information is not familiar, concrete versus abstract considerations are not relevant. For example, *Chicago* and *William Henry Harrison* are examples of concrete information. If learners are not familiar with these proper names, however, they will not be able to evoke a particular image of these phenomena. Conversely, a picture of Chicago or Harrison will not elicit any particular name (other than, perhaps, city or person) if such names are not familiar to the learner. Generally, concrete information has been found to be more memorable than abstract information; additionally, pictured concrete information has been found to be more memorable than verbally presented concrete or abstract information (Paivio; Paivio & Csapo, 1969).

Elaboration, in associative learning, refers to the linking component that connects stimulus and response terms. Jensen and Rohwer (1963), for example, have demonstrated that such meaningful, concrete verbal associates as *comb-glass* can be facilitated when mentally retarded learners are provided (or asked to generate) elaborations such as *the comb is breaking the glass*. Such elaborations have been demonstrated to be effective across a range of individual ability differences (Scruggs & Mastropieri, 1985; Taylor & Turnure, 1979). Odom and Nesbitt (1974), among others, have provided information that pictured elaborations can have a very positive effect on associative learning.

The above factors have been shown to be strongly related to learning and memory. Specifically, it seems likely that a given content that is at once meaningful, concrete, and well elaborated is more likely to be remembered than a content that is unfamiliar, abstract, and disjointed. It could be hypothesized, further, that meaningful, concrete information would be remembered best; meaningful, abstract information would be remembered less well; and that nonmeaningful information would be remembered the least. What appears unfortunate, however, is that implications from such research findings have not been readily translated into more effective educational methods and/or materials, particularly for learners characterized by failure to easily acquire such information. A major difficulty in using elaboration to improve instructional practice is in applying such elaborations to relevant school content, a content that superficially appears far removed from experimental associates such as *comb-glass* or *cow-ball* (Rohwer, 1968). Partly as a result of the problems

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in developing effective elaborations for school learning, simpler strategies such as rehearsal became popular in facilitating associative learning of inefficient learners (Becker, Engelmann, Carnine, & Maggs, 1982; Mastropieri, Scruggs, & Levin, 1987b).

Reconstructive Elaborations

One possible means of adapting ecologically valid content to elaboration strategies is by transforming information into more memorable pictorial formats. The presently described model of *reconstructive elaborations* provides a means for reconstructing content area information into more meaningful, concrete forms, and pictorially depicting elaborations of stimuli and responses. The manner in which specific information is reconstructed depends upon the level of meaningfulness or familiarity to the learner and the level of concreteness of the information. Such reconstructions can be characterized as *acoustic, symbolic,* or *mimetic.* Once reconstructed along these dimensions, as described below, pictorial elaborations can be provided.

Acoustic Reconstructions

Some information is not meaningful to the learner, although it may acoustically resemble information that is both meaningful and concrete. Such information includes unfamiliar names of people, places, and things, and unfamiliar vocabulary words. Such nonmeaningful information can be reconstructed by means of the *keyword* method (Atkinson, 1975). According to Mastropieri, Scruggs, and Levin (1985), "the recoding component of the keyword method serves to transform unfamiliar, nonmeaningful stimuli into more meaningful entities" (p. 40). Using the keyword method, unfamiliar stimuli are reconstructed into concrete, meaningful acoustic representations (keywords), which are then elaborated with responses by means of interactive pictures or images. For example, to learn that the Greek root *ptero-* means *winged*, the stimulus ptero- is transformed into the concrete, meaningful, and acoustically similar *tire*, and pictured in an interactive elaboration (e.g., a picture of a tire with wings). When asked to retrieve the meaning of ptero-, the learner first thinks of the keyword (tire), retrieves the interactive picture (a tire with wings) and provides the response (winged). Initially employed with learners of average or above-average ability (Atkinson, 1975; Pressley, 1977; Pressley, Levin, & Delaney, 1982), keyword and related mnemonics more recently have been shown to be extremely effective with handicapped or otherwise inefficient learners (Mastropieri & Scruggs, 1987; Mastropieri, Scruggs, & Levin, 1985; Pressley & Levin, 1987).

Keyword-type mnemonic strategies have been successful in facilitating associative learning for inefficient learners in a wide variety of content areas, including English vocabulary (Mastropieri, Scruggs, Levin, Gaffney,

& McLoone, 1985; Scruggs, Mastropieri, & Levin, 1985), foreign language vocabulary (McLoone, Scruggs, Mastropieri, & Zucker, 1986; Veit, Scruggs, & Mastropieri, 1986), geology (Mastropieri, 1983; Scruggs, Mastropieri, Levin, & Gaffney, 1985; Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1987), and natural history (Mastropieri, Scruggs, & Levin, 1987a; Veit et al., 1986). Such experimental treatments, compared with free study, imposed rehearsal or spatial organizing strategies (e.g., Scruggs, Mastropieri, Levin, McLoone, Gaffney, & Prater, 1986) have resulted in the largest effect sizes to date in the special education literature (Mastropieri & Scruggs, in press).

As successful as the keyword method has been, however, it must be noted that this strategy is most useful when the stimulus term (e.g., rhodochrosite, saprophytic, Zimmerman) is nonmeaningful and unfamiliar to the learner. Although such unfamiliar information constitutes an important component of content area learning (e.g., Who was William Henry Harrison?), it is by no means the only type of information taught in school. Much school learning requires the learning of new associations for meaningful, concrete information (e.g., What were the principal crops of early American pioneers?), as well as new associations for meaningful, but abstract stimuli (e.g., How did Washington's taxation policies influence the Whiskey Rebellion?). Although one could, in principle, construct keywords of meaningful-abstract as well as meaningful-concrete information, it does not seem parsimonious to establish additional retrieval links when it may be possible to build upon the existing meaningfulness of the information. In order to efficiently accommodate the variety of associative information encountered in content area school learning, two additional reconstructive elaborations are critical: symbolic and mimetic.

Symbolic Reconstructions

Some to-be-learned information is familiar to the learner, but is abstract, and therefore can not be easily pictured. Such information can be reconstructed symbolically and then depicted in a pictorial elaboration with its response. According to Paivio (1971), "the word *religion* may evoke an image of a church as an associative reaction, and a picture of a church might arouse *religion* as an associate, but both are likely to be mediated by the implicit verbal associate *church*. This would be an instance of concretization of an abstract referent" (p. 60). Other instances of abstract information that can be symbolically reconstructed include *liberty*, *U.S. policy*, and *Republicans*. Once symbolized, the abstract stimulus can be depicted interacting with the response information in an elaborative illustration.

Previous research on the keyword method has indicated that such symbolic encodings can be powerful facilitators of learning and memory, at least when used in conjunction with keywords. For example, Mastropieri, Scruggs, Levin, and McLoone, (1985) employed symbolic reconstructions to facilitate the learning of dichotomized mineral attributes. In order to teach that specific minerals could be classified as *hard* or *soft*, symbolic reconstructions were established whereby the meaningful but abstract attribute *hard* was represented by a picture of an old man, whereas *soft* was represented by a baby. In addition, Veit et al., (1986) developed symbolic reconstructions to represent attributes of dinosaurs. In this case, specific dinosaurs were depicted as representing the *early*, *middle*, or *late* period of the Mesozoic era by picturing the keyword proxy for the dinosaur name in an *early-morning*, *mid-day*, or *late-night* setting. Additionally, the colors *green* and *red* were used to symbolize whether the dinosaur was a herbivore or carnivore, respectively. In all the above instances of symbolic reconstructions, however, the materials constituted lists of factual information not based upon any specific curriculum. Furthermore, symbolic representations were always used in conjunction with a keyword strategy. In the context of the present model, symbolic representations need not interact with keyword mnemonic systems.

Mimetic Reconstructions

Some information is already concrete and meaningful to learners. In the psychological learning literature, such associates as *comb-glass* (Jensen & Rohwer, 1963), or *foot-sun* (Odom & Nesbitt, 1974) are presented together. Both associates may be familiar to subjects; what is necessary is that subjects learn that these items go together. In such cases, all that is necessary is that *mimetic* (representational) pictures depict the elaboration of stimulus and response information. Such information is found in content areas in which familiar attributes are linked with known phenomena and when the association itself is unknown. For example, some history texts (e.g., Rawls & Weeks, 1985) describe the fact that during World War I many soldiers became ill and died from diseases contracted in trenches. The terms *trench* and *sick soldiers* are concrete and meaningful to most learners. In this case, it is the connection between the two terms that may not be known. A mimetic reconstruction simply depicts trenches filled with sick soldiers to promote acquisition and recall of the response, World War I soldiers contracted diseases in the trenches.

Mimetic illustrations have previously replaced keywords in studies in which the stimulus information was thought to be already meaningful and familiar to the learner, thereby rendering the acoustic reconstruction unnecessary. For example, in teaching information about minerals, Scruggs, Mastropieri, Levin, and Gaffney (1985) did not employ a keyword for *diamond* because diamond was already familiar and concrete to subjects in this investigation. To show that diamond was used for cutting, a picture simply depicted a diamond being used for cutting. Because acoustic reconstructions were unnecessary (learners were simply told, e.g., "The keyword

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for *diamond* is diamond"), experimental materials for diamond were employed as part of the practice examples in that investigation and were not evaluated with the other keyword materials.

List Learning

One additional characteristic of the three mnemonic systems described above is that they are all intended to facilitate the acquisition of single responses to specific stimuli, similar to commonly found content area test items. Although previous research has indicated that multiple attributes of a single stimulus (e.g., mineral or dinosaur names) can be adapted to mnemonic elaborations (e.g., Mastropieri, Scruggs, Levin, & McLoone, 1985); Scruggs, Mastropieri, Levin, & Gaffney, 1985), such information, nevertheless, employed associative test items (e.g., What is the hardness level of calcite? What is the color of calcite? What is calcite used for?). In developing a model of relevance to all factual information, it was also important to include a mnemonic system that would facilitate the retrieval of lists of information; in the present instance, names of countries associated with each major European alliance prior to World War I. For retrieval of such information, a first-letter mnemonic strategy was incorporated within an acoustic (keyword) reconstruction of the (unfamiliar) name of each alliance. In this case, a keyword was developed for the name of each alliance (e.g., Central Powers). This keyword was then associated with a depiction of a word that provided an acronym for the nations involved in the alliance.

Purpose

The purpose of the present investigation was to determine whether the presently described model of reconstructive elaborations could accommodate an entire school content, and whether such an overall model would facilitate learning and delayed retention. With respect to the associative elaborations, it was further hypothesized that control condition students who received more traditional instruction would learn successively less as levels of meaningfulness and concreteness decreased (see above). In contrast, it was hypothesized that students taught via reconstructive elaborations would maintain overall high levels of performance across different levels of meaningfulness and concreteness of the target information because the provided reconstructed elaborations were all meaningful and concrete. Resulting between-condition effect sizes for the production test, then, were predicted to be smallest for the mimetic items, larger for the symbolic items, and largest for the acoustic items. Because such strategies are thought to be of critical importance to the school success of handicapped or inefficient learners (Pressley & Levin, 1987; Scruggs, Mastropieri, & Levin, 1987), the target population was drawn from a sample of mildly handicapped (learning disabled and mildly mentally handicapped) students.

Method

Subjects

Subjects were 30 junior high and high school students classified as learning disabled (LD) or mildly mentally handicapped (MiMH), and attending special classes as well as mainstream content area classes in a midwestern, urban school district. Students were classified as LD on the basis of persistent difficulties in learning basic academic skills or content, not attributable to overall deficits in intelligence, cultural deprivation, sensory impairment, or emotional disturbance. Students were classified MiMH primarily on the basis of IQ scores of 2 standard deviations below the mean with accompanying deficits in adaptive behavior. All students had been referred for persistent learning problems by regular classroom teachers, evaluated for learning disabilities or mild mental handicaps by a school psychologist, and classified as LD or MiMH on the basis of a multidisciplinary meeting attended by a psychologist, the student's teacher, a special education teacher, administrative personnel, and a parent, whose signed approval was legally necessary for initiation of special services. Although all students exhibited severe academic deficiencies, stated sources of this difficulty on Individual Educational Programs (IEPs) for the LD students were varied and included hyperactivity and attentional deficits, cognitive processing problems, and deficits in expressive or receptive language ability. The sample was intended to represent a range of characteristics typically found in special education classrooms and to provide broad support for the model, if effective.

The average age of the sample was 15.1 (*SD* = 12 months), and included 11 eighth graders, 10 ninth graders, and 9 tenth graders. Of the students, 28 had been classified LD; 2 had been classified MiMH. Of the sample, 63% (19) were male. Two of the students were of Hispanic background; the remaining students were white. Average Wechsler Intelligence Scale for Children—Revised IQ was 86.4 (*SD* = 12.2); mean grade equivalent score for reading, according to the Woodcock Johnson Psycho-Educational Battery, was 5.2 (*SD* = 1.7), or approximately 4 years below grade level, on average. Mean grade equivalent score for math, according to the Key Math test, was 5.9 (*SD* = 1.9). Most students exhibited substantial deficits in both areas, and had been attending special classes for the greater part of their years in school. Although all students received special education in basic skills, students chosen for this investigation were also attending mainstream content area classes.

Materials

Two sets of materials were developed for this investigation, for experimental and control conditions. Each set was in booklet form, 31 pages in length, and provided narrative information about World War I taken from

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a commonly used U.S. history textbook (Rawls & Weeks, 1985). The first 2 pages provided introductory information and a practice example. The 3rd and 30th pages contained a preview and review, respectively, of unfamiliar names and vocabulary words. Pages 4 and 5 described prewar alliance systems and listed the countries in each alliance. Pages 6 through 29 contained narrative descriptions of important people, places, and events of World War I. Both sets of materials employed the same format, with one major fact or list of facts per page, one illustration per page that referred to the fact or facts, and a narrative description of the target information that was identical for both conditions. Reading level of the text passages was assessed at about 6.3, using Fry's (1968) formula. An example of text used in both conditions is:

> World War I was the first major war in which airplanes were used. Both sides used them to bomb enemy-held towns, to scout out enemy positions, and to locate enemy warships. Seventy-one Americans became "aces," pilots who shot down five or more enemy planes. One of the heroes of the war was *Captain Eddie Rickenbacker*, an ace who shot down 26 German aircrafts.

The texts also employed prompts on each page to refer to the illustration, although specific strategy information differed as a function of experimental condition. The final page consisted of a summary statement and a reminder to think back to previous pictures and text when retrieving information, and was identical for both conditions.

In addition, two tests were developed that were identical for both conditions. The first was a production test and consisted of 26 directed questions from the text on the major facts. These test items corresponded to the eight meaningful-concrete (e.g., How were tanks used in World War I battles?), eight meaningful-abstract (e.g., Why were Americans more sympathetic to the Allied Powers?), eight nonmeaningful (e.g., Who was Eddie Rickenbacker?), and two serial list (e.g., Name the countries in the Central Powers) items taught and prompted within the lesson. The second, delayed recall test, was an identification test and employed multiple-choice and matching formats to assess the same items as those on the production test. An identification format was selected for the delayed recall test out of concern for possible floor effects that might have resulted from a delayed administration of the production test.

Experimental (reconstructive elaboration) condition. The first page of the experimental condition booklet explained the nature of the task and stated that different types of pictures were going to be presented to help the student remember the information. On the next page, an example of the keyword strategy was provided. The example explained that World War I started when Gavrilo Princip assassinated a leader of Austria-Hungary. To remember the information, the text explained, an acoustically similar keyword for Princip (prince) was provided, and a picture was presented in which a prince was depicted assassinating a leader of Austria-Hungary. The remainder of the text on that page provided specific retrieval information and practice answering the question, Who was Gavrilo Princip? The third page introduced the items from the target information for which keywords had been constructed and provided practice on supplied keywords (e.g., Eddie Rickenbacker = linebacker; George M. Cohan = cone).

Following the page of keyword information were 26 pages of target information, of which 2 pages contained multiple-item (serial list) responses, and the next 24 pages contained single-item (associative) responses. The first 2 pages described the countries in the Central Powers and Allied Powers alliances and provided a mnemonic first letter strategy and accompanying picture for each. For example, to learn that the Central Powers were represented by Turkey, Austria-Hungary, and Germany students were shown a keyword representation of Central Powers (Central Park) and provided a picture of people playing *tag* in Central Park. The text instructed the learner, when asked for countries in the Central Powers, to think of the keyword Central Park and think of the picture of people playing tag in Central Park. They were then told that the word *tag* was a first letter strategy for Turkey, Austria-Hungary, and Germany and to use this mnemonic picture to help retrieve the countries of the Central Powers, when asked.

The remaining 24 target items consisted of single-item response information and were divided into three groups of eight items per group with respect to meaningfulness and concreteness and reconstructed according to these dimensions by means of three types of elaborations. Concreteness was determined by the extent to which target information could be literally represented in a picture, given that it was likely to be familiar to learners. Level of meaningfulness of the target information was established through extensive pilot testing with students of the same age, grade, and ability levels, and several adaptations of the materials were made on the basis of this pilot testing. *Mimetic* elaborations were those that provided a pictorial interaction of meaningful-concrete stimulus items with their responses. For example, to teach that German submarines could not come to the surface of the water to seize enemy shipping without being shot, a line drawing was provided of a German submarine rising to the surface and being shot by the deck guns of an enemy ship. *Symbolic* elaborations were those that provided a pictorial interaction of meaningful-abstract stimulus items with their responses. For example, to teach that the United States at first remained neutral when conflict broke out in Europe, U.S. policy was reconstructed as a picture of Uncle Sam. In a line drawing, Uncle Sam was shown standing on the American side of a globe, looking over to Europe in which war was raging, and stating, "It's not my fight." Finally, *acoustic* elaborations were those that provided a pictorial interaction of nonmeaningful, unfamiliar stimuli with their responses. The keyword method was used to transform nonmeaningful stimuli into acoustically similar proxies, and interactive pictures were provided in the manner described in the Gavrilo Princip example, above.

The eight mimetically, eight symbolically, and eight acoustically reconstructed pictures were presented in order consistent with chronological events, but were intermixed throughout the narrative. Each page contained a narrative description of the information, a line drawing of the elaboration, and retrieval instructions. Following these pictures, a one-page review of unfamiliar names, words, and accompanying keywords was provided (without reference to response information or elaborative pictures).

Control condition. The control condition materials paralleled the experimental condition materials with respect to the order of item presentation, the content covered, the textual information for all items (excluding strategy information), and the number of pages. Page 1 explained that the forthcoming information concerned World War I and that a variety of pictures and maps would be shown along with the text passage to help facilitate learning. Page 2 provided the identical passage regarding Princip's assassination of the leader of Austria-Hungary; however, the retrieval instructions (to think back to the picture to help remember the information) made no mention of the keyword method, and the illustration accompanying the passage was a line drawing of Gavrilo Princip. Page 3 provided a listing of the nonmeaningful words and names as in the experimental condition, without the inclusion of corresponding keywords. Learners were provided practice at pronouncing and looking at the names, rather than learning keywords. The next 26 pages contained the target information. Pages 4 and 5 presented information on the alliance systems and provided map line drawings with the countries in each system labeled. Pages 6 through 29 contained the passages parallel in form to those in the experimental condition, with the exception that all illustrations were representational, rather than reconstructive, and depicted the stimulus or response information, without an interactive elaboration, regardless of item type. For example, the illustration for the German submarine simply depicted a German inside his submarine while he was looking through a periscope. Items involving names of World War I figures included line drawings of those figures. Maps indicating the countries involved in each alliance accompanied the passages on the Central and Allied Powers. Following the narrative information, a final page reiterated unfamiliar names and words (without reference to responses to these items) as in the experimental condition, with the exception that keywords were not provided.

Procedure

Students were stratified by grade level and assigned at random to experimental or control conditions. All students participated individually.

As students entered a quiet area away from their classroom, in the same school, they were provided with individual instruction by one of four trained experimenters (three female, one male), each of whom saw an equivalent number of students from each condition. Experimenters read each page to each student, who was asked to read along silently and attend to illustrations when directed. Experimenters followed written materials verbatim, questioned learners as provided in the text, and provided feedback and questioning, when necessary.

Time on task was equated across groups, with students in each condition receiving the same amount of time on each page of the booklet. These times were not constant for each page but varied as a function of meaningfulness of the information and the relative speed the information could be conveyed, determined from pilot testing. Time per page ranged from 45 s to 2 min, 15 s for introduction, summary, and practice pages; and either 45 s or 60 s for target information. Individual page times were written in the upper right hand corner of each page; the cumulative time was written in the lower right hand corner. These written times were used as a guide for experimenters to direct the pace of the presentation and to ensure its consistency across conditions. Overall, all students, experimental and control, received 28 min of instruction, including 4.5 min of introduction and practice information.[1]

After the instructional period, students were given a 90-s filler activity in which they were asked to write their name, age, birth date, grade, homeroom teacher's name, and school on an envelope. Students in both conditions were then given identical directions including: "This test is hard and you are not expected to get all the items correct. Please just really try your best." Immediately after this, each student was administered the immediate production test, in which they were asked to name the countries in each of the two alliances and answer each of the 24 target information questions. Either 3 or 4 days later (delay interval was equivalent across conditions), students were given the surprise recall test. Three students (one experimental, two control) were absent during implementation of the delayed recall measure and were given the measure 1 day later. A fourth student was absent for over a week after the immediate production test and therefore was not included in the delayed identification test.

Scoring

On the immediate production test, students were awarded one point for each answer that provided information considered to be of critical importance to the test item. Incomplete but partially correct answers were given ½ point. Answers were first scored by two independent raters, unaware of condition membership, who discussed scoring conventions prior to and subsequent to scoring, and reached 99% agreement on a random sample of 27% of all tests. Each of the 24 associative items was awarded either 0 points, ½ point, or 1 point. For each of the two serial recall items referring to countries in either alliance, responses were given 1 point for each of four Allied Powers correctly named, and 1 point for each of three Central Powers correctly named, for a possible total of 7 points. The 31-item delayed recall identification test was scored independently by two scorers unaware of experimental condition who reached 100% agreement.

Results

Means and standard deviations for each are given in Table 1. For the immediate production test, data were entered into a multivariate analysis of variance (MANOVA) with each of the four item types as dependent variables. These four item types were (a) serial list, (b) meaningful concrete, (c) meaningful abstract, and (d) nonmeaningful. The resulting multivariate effect was significant, $F(1,28) = 23.38$, $p < .001$. Subsequent univariate t tests were statistically significant for each item type, with ts (28) of 2.32 ($p = .028$), 2.37 ($p = .025$), 3.40 ($p = .002$), and 4.57 ($p = .000$), respectively, for serial list, meaningful-concrete, meaningful-abstract, and nonmeaningful items. Obtained mean-difference effect sizes, shown in Table 1, indicate that, for the three associative item types, effect sizes increased as the level of meaningfulness and concreteness decreased, as predicted.

Total scores on the delayed identification test were compared by means of a t test. Again, students in the experimental condition significantly outperformed students in the control condition, $t(27) = 2.22$, $p = .035$.

Discussion

The results of this investigation suggest that the use of reconstructive elaborations as described in this paper can facilitate acquisition of an entire domain of content area information by handicapped learners. Validity for the model was supported by the fact that such students provided with reconstructive elaborations outperformed control students by a factor of

TABLE 1

Means, standard deviations, and effect sizes (ES)

	Experimental mean	Control mean	ES
Item type (immediate test)			
Serial list	3.9 (2.3)	2.1 (1.3)	1.00
Meaningful concrete	6.4 (1.7)	4.3 (2.0)	.30
Meaningful abstract	4.0 (1.5)	2.1 (1.6)	1.19
Low meaning	4.6 (1.3)	1.6 (1.3)	1.67
Total test type			
Immediate (production)	13.9 (5.3)	10.6 (3.9)	2.13
Delayed (identification)	21.6 (5.3)	17.3 (4.5)	.96

Note. Standard deviations in parentheses.

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nearly 2:1 on immediate production recall, as well as the fact that increasing effect sizes paralleled decreasing levels of meaningfulness and concreteness, as predicted. These increasing effect sizes appear to have been due to decreasing performance in the control condition, as information became less concrete and meaningful.

In addition to the single-response item types, a mnemonic first-letter strategy was included in the materials because this type of prompted list response is frequently called for in content area learning and the strategy is an appropriate one, given that responses are familiar and each list can be effectively associated (by elaboration) to its stimulus (Mastropieri & Scruggs, 1987). This strategy was also found to be effective.

Results of the delayed recall test indicated that positive effects of the reconstructive elaborations were still evidenced several days after initial presentation. Taken together with positive delayed recall effects obtained in previous mnemonic investigations with LD populations (Mastropieri, 1983; Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1987; Veit et al., 1986), these effects provide further evidence for the potential of such elaborations in facilitating long-term, as well as immediate recall.

Previous research has documented the potential power of such mnemonic techniques as the keyword method in improving the school learning of mildly handicapped students (Mastropieri, Scruggs, & Levin, 1985). Nevertheless, an important limitation of the keyword method is its restriction to items (typically, names of things) that are unfamiliar to the learner. In order to be adaptable to a wide variety of school content (rather than specific lists of information), it is necessary to incorporate the keyword method within the larger context of elaboration in school learning. Within the present context of mimetic, symbolic, and acoustic reconstructive elaborations, it has been seen that ecologically valid content can be effectively adapted, with substantial gains in learning efficiency. Such an outcome was far from a foregone conclusion, as it was uncertain whether mildly handicapped learners would be able to make use of different elaborative systems within the same lesson without becoming confused. Nevertheless, results from this investigation suggest that such learners can make efficient use of a variety of elaborations to markedly improve their chances of school success in content area classes.

Findings of the present investigation provide implications for teachers as well as curriculum developers. Because few mnemonic materials presently exist for classroom learning experiences, it is possible that teachers themselves can adapt important content via the model of reconstructive elaborations. Mastropieri and Scruggs (1989) have described procedures for analyzing school content and adapting it to the presently described model. Special education teachers have recently applied these procedures to develop materials and to teach critical content in anatomy (Whittaker, Mastropieri, & Scruggs, 1988), life science (Mastropieri, Emerick, &

Scruggs, 1988), and social studies (Plummer, Mastropieri, & Scruggs, 1988). In order to develop pictorial elaborations, teachers used stick figures, cutouts from magazines, or volunteer high school art students. In all cases, students taught via reconstructive elaborations outperformed students taught by more traditional methods.

As we have argued previously, mnemonic instruction should not be regarded as a panacea for inefficient learners. Additional instructional strategies may be necessary to promote *fluency* of responding (Mastropieri & Scruggs, 1987), and *application* of learned information in appropriate contexts (Scruggs & Mastropieri, 1988). With respect to the present instructional objective, however, that students efficiently acquire important content area information, the experimental treatment was highly successful. The present results suggest that a system of reconstructive elaborations, based upon a textual analysis of concreteness and meaningfulness, may provide a model whereby all elements of content area learning can be improved. Future research can help provide further information on, and possible extensions of, this model.

Authors' Note

The research reported here was supported in part by a grant from the U.S. Department of Education, Special Education Programs, No. GOO8730144. The authors would like to thank Steve Stavros, principal, and Ramona Engle Stavros, special education coordinator, both of Morton Senior High School, Hammond, Indiana, for their assistance in the implementation of this project. We would also like to thank Dr. Jim Hamilton, of the Office of Special Education and Rehabilitative Services, for his feedback on an earlier version of this manuscript.

Note

[1] During implementation, 4 of the 30 students exceeded or fell short of the implementation period by 1 to 2 min; however, these times did not vary as a function of condition, and the overall implementation time was identical for the two groups. In addition, 2 students were dropped due to interruptions during the experimental session (e.g., fire drill).

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Appendix Q

Scruggs, T.E., & Mastropieri, M.A. (1990a). The case for mnemonic instruction: From laboratory research to classroom applications. Journal of Special Education, 24, 7-32.

THE CASE FOR MNEMONIC INSTRUCTION: FROM LABORATORY RESEARCH TO CLASSROOM APPLICATIONS

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This article describes the design and execution of a systematic body of research using, as an example, the authors' own mnemonic strategy research. We describe the evolution of this research, from theory-driven laboratory research to long-term classroom applications of the effectiveness of curriculum-relevant mnemonic strategies. We argue that different experimental materials, different implementation procedures, and different experimental designs are necessary at different stages of the development of this research, and provide examples to support our positions. Finally, we describe the necessary contribution of other, independent researchers in supporting the external validity of the findings.

Over the past decade, the authors have completed a number of experimental investigations concerning mnemonic (memory-enhancing) strategy use in exceptional populations. These investigations have taken us from initial explorations of spontaneous strategy use by gifted adolescents to broad implementation of a variety of powerful mnemonic strategies that dramatically enhanced the classroom success of learning disabled (LD) and mildly mentally handicapped students. These findings have also been supported by other independent researchers, primarily in dissertation research. Although we believe that there is an important need for further research on mnemonic strategy use in exceptional populations, we also believe that we have reached a point in our research where we can offer wholehearted support for the use of mnemonic techniques in the teaching of mildly handicapped students.

The evolution of the research documenting the effectiveness of mnemonic strategy use has followed a relatively systematic and logical progression. This progression has provided for a substantial number of replications as well as additional extensions of previous findings. These studies taken as a whole, rather than separately, provide the strongest support for the effectiveness of mnemonic instructional techniques. The overall rationale behind these individual studies, however, may be unclear to readers. Individual research studies, reported in a wide variety of journals both in the special education and educational psychology literatures, may be unavailable to some readers. In addition, differences in journal turnaround time have resulted in discrepancies between time of execution and time of publica-

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Article Selection

In selecting articles for publication, manuscripts initially are assigned to one coeditor and screened for (a) appropriateness of content for JSE (see description above), (b) adherence to guidelines specified in the third edition of the *Publication Manual of the American Psychological Association*, (c) readability of text, and (d) explicit statement of implications for the practice of special education. When these criteria are met, the manuscript is sent for blind review to two or three evaluators who have documented expertise in the content area addressed and/or methodology employed in the article. When reviews are returned, the coeditor assigned to the article considers reviewers' comments, independently evaluates the manuscript, and makes an editorial decision to reject, request a revision with the stipulation of further peer review, request a revision subject to review by the coeditor, or accept as is. Authors receive copies of reviewers' comments, which preserve reviewers' anonymity. Reviewers are informed of the final disposition of the article and receive all reviewers' comments, which reveal reviewers' identities but maintain authors' anonymity.

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tion of many of these studies. Previous reviews of mnemonic instructional research in special education (e.g., Mastropieri & Scruggs, in press; Mastropieri, Scruggs, & Levin, 1985a, 1987b; Scruggs & Laufenberg, 1986; Scruggs, Mastropieri, & Levin, 1987) are either outdated or fail to address directly the decisions we made in attempting to establish a credible line of research in this area.

The purpose of this article is to present the case for mnemonic instruction, based on our nearly decade-long program of research. In doing so, we provide a rationale for our choice of learning tasks, designs, and implementation formats. We argue that research designs, materials, and procedures used at the beginning of a line of research will necessarily differ from designs, materials, and procedures used at later stages in the research, and offer our justification for these differences. We also attempt to support our own position that research intended to influence instructional practice should be designed as a long series of individual but interdependent investigations, rather than one or two major studies that attempt to answer most or all relevant research questions at once. Finally, we describe the findings of independent researchers who have also explored mnemonic strategies and discuss the necessary role of independent replication and extension.

FOUNDATIONS

Meaningfulness, Concreteness, and Elaboration

Theoretical and empirical foundations for the use of mnemonic strategies with exceptional populations have been provided from the experimental learning literature, as well as literature documenting learning deficiencies of exceptional populations. For many years, researchers (e.g., Underwood & Schulz, 1960) have reported that learning is strongly influenced by *meaningfulness*. That is, the more meaningful information is, the more easily it is acquired. (Underwood & Schulz, 1960, described *familiarity* as a "natural" synonym of meaningfulness.) It has also been reported (e.g., Paivio, 1971) that *concreteness* plays an important role in learning success, and that semantic *elaboration* of stimulus and response information (e.g., Rohwer, Raines, Eoff, & Wagner, 1977) is known to facilitate associative recall. Taken together, these theories (as well as common sense) suggest that concrete, meaningful (or familiar), elaborated information will be more easily learned than, for example, nonmeaningful (or unfamiliar), abstract, and unelaborated information. Unfortunately, in the reality of school learning students are likely to find that information to be learned is more aptly described by the latter characterizations.

Individual Differences

How do concreteness, meaningfulness, and elaboration interact with individual differences? In a series of investigations involving highly able (gifted) as well as more typical learners, Scruggs (1982), Scruggs and Cohn (1983), and Scruggs and Mastropieri (1985) reported that, when confronted with pairs of unfamiliar paralogs (nonsense words) to learn, highly able learners were able to reconstruct these unfamiliar elements into more meaningful units, and effectively elaborate

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them with their associate elements, to a greater extent than were more typical learners of their own age. For example, given the paralog pair BODKIN–NOSTAW to learn, typical junior high school students were likely to report, "I said the words over and over to myself." Their gifted counterparts, on the other hand, were more likely to report effective reconstructions and elaborations, such as, "I thought, 'The BODy has a NOSe.'" Such a reconstruction transforms essentially nonsense words into concrete, meaningful representations and effectively elaborates stimulus with response information to facilitate later retrieval. When asked for the associate of BODKIN, then, the learner can think of the reconstructed BODy and easily remember the meaningfully elaborated response. When students reported using such strategies, their probability of remembering the word pair was much greater than when they reported lower level strategies, such as rehearsal, which did not take meaningfulness, concreteness, or elaboration into account.

Supported by the experimental learning literature, we saw that independent reconstructive and elaborative strategy use predicted learning, to a similar degree, in both average and high-ability groups. What differentiated the groups was the relative ability to spontaneously generate such strategies. The gifted students scored higher because of their ability to create these strategies more frequently than did their more typical age peers. These investigations did not demonstrate that such strategies could be provided to learners to increase their learning, or that learners could be taught to generate independently such strategies. However, they did suggest that independent strategy use, along the dimensions of meaningfulness, concreteness, and elaboration, was strongly predictive of learning success (more so than "ability" characterizations of students) and would be a fruitful avenue for future research. In addition, similar research previously conducted with mentally retarded learners (see Taylor & Turnure, 1979, for a review) had suggested that similar deficiencies in strategy use differentiated mildly mentally handicapped from more typical learners, and that provision of appropriate elaborations facilitated their performance on these experimental learning tasks.

Strategy Deficits. More recently, researchers investigating cognitive strategies used by learning disabled students have reported deficiencies in spontaneous generation of effective memory strategies. Researchers such as Ceci (e.g., Baker, Ceci, & Herrmann, 1987; Ceci, 1985) have suggested that the field could more profitably investigate the type of learning strategies that could be taught to LD students, rather than, for example, more global investigations of general processing deficits.

> Instead of advocating intervention plans that are directed at remediating alleged cerebral insult or dysfunction, a more profitable approach to children with semantic processing difficulties [illegible] is to train purposive information processing strategies like elaborative encoding, chunking, anticipation, type 2 rehearsal, and so on. (Ceci, 1985, p. 219)

It had also become clear that training designed to remediate such hypothesized processing deficits as perceptual-motor, modality, or psycholinguistic abilities had failed (Kavale & Forness, 1985), and that it may be most profitable to turn research attention to the direct training of the cognitive processes used in learning and remembering specific components of school-relevant information. In addition to

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a stronger theoretical grounding, strategy-deficit theories had more specific implications for teaching than did more general processing theories.

Some earlier elaboration research had been conducted with exceptional populations but, in spite of being widely cited, failed to produce any significant impact on educational practice. Jensen and Rowher (1963) trained mildly mentally handicapped adults to learn pairs of concrete, meaningful information (e.g., FROG–POCKET, COW–BALL) by creating sentences that effectively elaborated the two terms (e.g., "A frog jumped in the pocket," or, "The cow kicked the ball"). Trained subjects learned many more word pairs in the same amount of time than untrained subjects; however, the instructional implications of such research were uncertain due to the lack of content validity of the experimental materials: Exactly what school learning tasks could such experimental tasks be said to represent? The history of verbal elaboration research in the 1960s and 1970s (see Taylor & Turnure, 1979) suggests that researchers at that time were primarily interested in addressing more basic research questions involving optimizing performance or inducing strategy transfer on experimental lists, rather than exploring school-relevant applications of these findings.

Possibly due to the lack of such task relevance, models of special education instruction derived at least in part from behavioral, rehearsal-based theories (Thorndike, 1931) began to replace process training instruction (Becker, Engelmann, Carnine, & Maggs, 1982). We have argued that rehearsal models, by making use of extensive repetitions, do facilitate learning in the long run by promoting a kind of familiarity; however, instructional models that effectively link new, unfamiliar information to a previously established knowledge base of concrete, meaningful information are more likely to result in rapid, efficient acquisition of school-relevant content.

INITIAL LABORATORY INVESTIGATIONS

Based upon previous research with normal and exceptional learners, it seemed that strategy use, either externally provided or spontaneously generated, would be more likely to positively influence learning than would more global process interventions, such as perceptual motor training, or behaviorally oriented interventions that rely upon rehearsal and externally provided reinforcement. But what strategic intervention could deal with the previously reported difficulties with task relevance? Reconstructive mnemonic strategies such as the keyword and pegword methods held great promise.

The keyword method had been described previously in popular memory-improvement books (Lorayne & Lucas, 1974); however, it was first investigated scientifically by Atkinson (1975), in the learning of foreign vocabulary words. In learning that the Spanish word *carta* means "letter," for example, the learner is first shown (or prompted to generate) a keyword for carta. Since carta is semantically nonmeaningful to a novice learner, the only dimension for meaningful reconstruction is acoustic. In other words, at this point the only thing the learner knows about carta is its sound. In this case, *cart* is a good keyword for carta, because it is acoustically similar to the target word and is concrete, and therefore easily

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pictured. An elaborative picture, then, could show a *letter* (definition of carta) in a grocery *cart* (keyword for carta). What is elaborated, then, is not the stimulus and the response, but a concrete, meaningful proxy acoustically tied to the stimulus (carta) effectively elaborated (shown interacting) with the response (a postal letter) (for more examples see Mastropieri, 1988).

Similarly, the pegword strategy (Bower, 1970; Miller, Galanter, & Pribham, 1960) employs acoustic rhyming reconstructions for numbers (one is *bun*, two is *shoe*, three is *tree*, etc.), which are then elaborated with corresponding numbered or ordered information. Lebrato and Ellis (1974) employed these strategies with a sample of mentally retarded learners and concluded that the strategy had been very effective for facilitating recall of number-word pairs.

> Imagery mnemonics may be a powerful tool in increasing learning and retention of educational materials, many of which must be learned in a rote fashion. In view of the poverty of truly special training and educational methods for retarded persons, this method bears careful and intensive study. (pp. 712-713)

Similar to the Jensen and Rohwer (1963) investigation, the experimental materials used (e.g., 1—*car*, 2—*flag*, 3—*clock*) provided an effective test of the strategy but failed to demonstrate educational relevance. However, we considered keyword and pegword strategies potentially very important, because the reconstructive component could help transform unfamiliar school-relevant content into familiar, concrete proxies, while the elaboration component could help assure a strong association between known and unknown information. We therefore began a series of investigations directed toward evaluating school-relevant applications of these strategies with exceptional populations.

Design Considerations

In our initial investigations, we were concerned with determining whether school-relevant mnemonic strategies could *ever* be effective with exceptional learners. At this initial stage of a program of research, it is important that the research design be as tightly controlled as possible, so that any benefit of the particular teaching technique might be noticed. To avoid a Type II error (i.e., that tangible differences due to treatment are not observed), it is important to do everything possible to maximize treatment effectiveness. These manipulations could include the following:

1. One-to-one teaching and testing situations, using trained experimenters, allow for the least possible experimental error from such extraneous variables as attention, inappropriate behavior, peer interaction, or less-than-optimal implementation. Additionally, individual implementations allow for completely random assignment to treatment conditions and avoid "independence" concerns that arise when treatments are administered in groups.

2. Brief, intensive experimental sessions reduce the possibility of experimental error due to interference, fatigue, or declining attention.

3. Experimental materials that test only the effectiveness of the strategies in question, and which are thought to be *highly unfamiliar* to learners, will maximize

treatment effectiveness. Materials that are likely to be familiar or even partially familiar can introduce experimental error due to prior knowledge. That is, the subject responds correctly not because of the effectiveness of the teaching strategy, but because he or she already knows the information being taught. Random assignment to treatment groups can reduce concerns of differential effects of prior knowledge; however, if subjects already know, for example, 20% of the experimental content, that previously learned information will not discriminate among treatments and will reduce the experimental power of the design.

4. Treatments should be only one session in length. Treatments that last longer than one session are vulnerable to subject attrition, which can seriously threaten the validity of any findings. Longer treatments are also vulnerable to any information or attitudes the student may acquire between treatment sessions. For instance, a student may become interested in the information being taught and read about it at home, between sessions. It is also possible that students taught certain information over time could discuss this information among themselves between sessions. At best, this could invalidate assumptions of "independence"; at worst, it could represent across-treatment contamination (e.g., if students receiving an experimental treatment explain this treatment to control group students). Any of these possibilities could seriously compromise conclusions of a particular investigation. On the other hand, one-session treatments afford no such possibilities for validity threats, especially if students are monitored while the treatment is being conducted, assuring that students who have just recieved the experimental treatment do not have the opportunity to interact with students who have not had the treatment.

5. It is also helpful, at this early stage of a research program, to employ only a small number of treatment conditions, for example, just two or three treatments. Such a small number of treatment conditions allows for greater statistical power on necessary pairwise comparisons. Although limiting the number of treatment conditions also limits the number of research questions that can be addressed, additional experiments can be planned to address additional questions.

Task Considerations

We employed designs containing the above mentioned features in conducting our initial mnemonic investigations. One of our first experimental tasks was learning the hardness levels of North American minerals, according to Moh's scale. The mineral hardness scale is ordinal, in which a higher number denotes a harder mineral. For instance, any mineral with hardness level 6 is harder than any mineral with hardness level 5. The scale ranges from 1 to 10, with diamond, the hardest mineral, representing the only instance of hardness level 10. We chose the learning of mineral hardness levels for several reasons. First, they were, we felt, virtually certain to be unknown by our targeted populations of learning disabled and mildly mentally handicapped students of junior high school age. Second, they afforded an excellent test of the utility of both keyword and pegword strategies, since learning mineral hardness levels would involve learning both a keyword for the mineral name and a pegword for the associated hardness number. Third, although it is difficult to assert that learning and remembering mineral hardness levels is a

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"typical" school learning task (it was, however, among the objectives of the district we worked in), it did represent a significant advance toward classroom-relevant materials from the earlier experimental associates, such as FROG–POCKET or 2-LADDER.

Research on Mineral Hardness Levels

In an initial investigation (Mastropieri, 1983, reported in Mastropieri, Scruggs, & Levin, 1985b), LD students were assigned at random to one of three conditions and taught individually mineral hardness levels via either mnemonic condition, a rehearsal-based picture control, or a free study condition. Mnemonic condition students were taught keywords for the mineral names and pegwords for the numbers 1 through 10. During the same time, rehearsal-based and free study condition students received an equivalent amount of time interacting with the experimenter, discussing background information on minerals. During the instructional period, mnemonic and rehearsal-based condition students were shown pictures and given instruction appropriate to each condition at a pace of 30 seconds per mineral. In the mnemonic condition, for example, students were shown a picture of a *horn* with a bee *hive* in it, and were told,

> Hornblende is number 5 on the hardness scale. The keyword for hornblende is *horn*, and the pegword for 5 is *hive*. Remember this picture of a *horn* with a *hive* in it. When I ask you about hornblende, first think of the keyword, horn, think back to the picture with the horn in it, remember that there is a hive in the horn, and give me the correct answer, "5." What is the hardness level of hornblende? [Provide feedback.] What do you do when I ask you about hornblende? [Provide feedback as needed.]

In the rehearsal-based condition, students were shown color photographs of each target mineral for the same amount of time as in the mnemonic condition (30 seconds), while the experimenter said, for example, "Hornblende is number 5 on the hardness scale. What number is hornblende on the hardness scale? Good, hornblende is 5." [Provide feedback as needed.] This condition provided for a direct comparison between mnemonic-based and rehearsal-based instruction, with rate of presentation of new content held constant. In the free study condition, students were provided with a variety of study materials and told to use whatever method they felt was best for studying the information. This condition provided, in addition to an additional control condition, a means of evaluating the rehearsal-based condition per se. Since this was a very early test of the potential efficacy of keyword-pegword strategies, we believed that the purely random assignment, individual presentations, brief, intensive treatments, and single experimental sessions would contribute to maximizing experimental power.

The results of this experiment indicated that mnemonically instructed students reliably outperformed students in the other two conditions, whose performance did not statistically differ. Not only was the overall result statistically significant, it was seen that the differences between mnemonic and the other two conditions were substantial: an average of 79.0% correct in the mnemonic condition, versus an average of 27.9% correct in the other conditions. Interestingly, the two comparison conditions did not differ significantly from each other, underlining the poverty of rehearsal-only methods when content is unfamiliar. Finally, a 24-hour "surprise"

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delayed recall test reported by Mastropieri (1983) revealed a statistical interaction, indicating that the students in the comparison conditions soon forgot what little they had learned, while mnemonically instructed students actually remembered slightly *more* information 24 hours later than they had earlier.

This finding of mnemonic superiority was replicated on a small sample of mildly mentally handicapped students (Mastropieri, Scruggs, & Levin, 1986, Exp. 2). Because of the small number of students available for the investigation ($n = 8$), we used a within-subjects crossover design, in which each student learned eight minerals via mnemonic instruction, and eight additional minerals via rehearsal. Treatment order and target information were counterbalanced to ensure that between-condition differences in treatment order or relative information difficulty could not differentially influence outcomes.

The results of these investigations provided important initial information regarding the potential of mnemonic instruction of mildly handicapped students. Nevertheless, many important questions remained to be addressed. The use of individual experimenter-led presentations, single sessions, and experimental lists achieved important statistical power but left untested questions of group, teacher-led instruction with actual school curricula. However, before we initiated such large-scale implementations, we elected to replicate our findings and further test potential of mnemonic instruction for teaching different types of information.

Multiple Attributes

Designing the Experimental Condition. Upon examining the results of the Mastropieri, Scruggs, and Levin (1985b) investigation, we began to wonder *how much* information could be incorporated within a single mnemonic picture. With the incorporation of different types of information, different mnemonic systems would be necessary, and the information-processing load on our target populations would necessarily be much greater. For example, what if, instead of teaching a single mineral and associated hardness level, we were to teach hardness levels, colors, and common uses associated with specific mineral names? Could all such information be incorporated mnemonically in a single picture, or would disabled learners be able to absorb only a single mnemonically elaborated fact? To address these questions, we developed a set of eight mnemonic pictures representing these three attributes of each of eight common minerals. We retained the pegword for the hardness level, but also integrated within the picture the color of the mineral, by coloring the pictured keyword, and provided an interactive mimetic (representative) picture of the common use. Thus, to show that crocoite was 2 on the hardness scale, orange in color, and used by collectors for displays, we constructed a picture of *orange* (color) *crocodiles* (keyword for crocoite), wearing *shoes* (pegword for hardness level 2) in a *display case* (common use). We planned for 30 seconds of presentation time per picture, as in the Mastropieri, Scruggs, and Levin (1985b) investigation, to test whether we could present three items of information at the same rate of presentation in which we had previously taught only one item of information.

Designing Control Conditions. We were also concerned about our design of comparison conditions. Frequently overlooked is the fact that the conclusions of

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research investigations have as much to do with the control or comparison conditions as they do with the researcher's treatment of choice. Lovitt (1988) has aptly cautioned against the use of comparison conditions that are insufficiently described or do not represent state-of-the-art treatments. Borkowski and Buchel (1983) have argued that, when evaluating specific instructional strategies, the most effective control condition should represent the best available treatment known at the time. The outcomes of instructional research are of little value if they merely document that a specific treatment is reliably better than no treatment at all, or a mediocre and poorly operationalized alternative treatment.

In light of our concerns about alternative treatments, we aimed for treatments that would also replicate and extend our comparison conditions. Specifically, we were concerned with our previous rehearsal-based condition, which controlled for the overall pace of content presentation but may not have been the most effective use of rehearsal-based instruction, since it did not include faster paced presentations and cumulative review of previously rehearsed information. We were also concerned that rehearsal-based conditions may be more effective if less content were presented at one time. That is, more total information may be learned if less potentially confusing content were introduced at one sitting. Therefore, in addition to a free study condition, we included fast-paced instruction, immediate feedback, and cumulative review throughout the lesson; however, in one condition, we attempted to teach three attributes each of only four rather than eight minerals, in the same amount of time. We argued that, conceivably, 100% of the information could be learned about four minerals, whereas perhaps only 40% of the information might be learned about eight minerals. If this happened, it would mean that we had inhibited the performance of students in the first rehearsal-based condition by introducing too much content, and that students taught *less* could actually learn *more*. In addition to the two (fast-paced and slower paced) rehearsal-based conditions, we also added a free study condition, as in the previous experiment, as a control for the rehearsal-based methods per se.

In the previous investigation (Mastropieri, Scruggs, & Levin, 1985b), we had replaced mnemonic-condition keyword and pegword training, in the comparison conditions, with interaction with the experimenter on the general topic of minerals. At that time, we did not substitute the keyword instruction time for additional content instruction in comparison conditions, because mnemonic students were receiving strategy-relevant information only, and not direct training of minerals and associated hardness levels. However, we decided for this and future experiments to replace time spent in keyword and pegword training in the mnemonic condition with additional direct instructional time on the target content in the control condition. Therefore, for the remaining studies we conducted, control condition students actually received *more* instructional time (up to 30% more) for target information than did mnemonic condition students, who needed additional time to study keyword and pegword reconstructions before being presented with the actual content. This manipulation afforded the most rigorous possible test of mnemonic instruction, and more accurately met the description of "best available treatment" for the control condition.

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Results. In this experiment (Scruggs, Mastropieri, Levin, & Gaffney, 1985), as well as the subsequent experiments, mnemonic instruction resulted in substantially (and significantly) higher levels of learning than did control conditions, and even resulted in a higher *percentage* of content learned than when attributes of only four (rather than eight) minerals were taught! In addition, analysis of each type of attribute (hardness, color, use) revealed that LD students were able to retrieve (presumably through imagery) colors as well as representational pictures, and these colors could be interpreted meaningfully. Perhaps even more surprisingly, we found that rehearsal-based comparison conditions resulted in levels of recall that were no higher than free study conditions. This was a startling surprise to us because we believed that experimenter-led, fast-paced instruction with immediate feedback and cumulative review was virtually certain to outperform free study conditions. (In fact, in the first experiment, one of us predicted that rehearsal would prove more effective than mnemonic instruction.)

In a follow-up experiment (Mastropieri, Scruggs, McLoone, & Levin, 1985), we decided to teach, not specific attributes of minerals (hardness = 2; color = orange; use = displays), but dichotomized attributes of these minerals (soft vs. hard; light vs. dark color; home vs. factory use). The reason we chose this task was that we wanted to know whether we could portray symbolically (rather than with representative pictures) mineral attributes. In this case we used, to portray hardness, an old man (hard) or a baby (soft); to portray color, blackened-in keyword (dark) or not-blackened-in keyword (light); to portray use, a home scene (home use) or a factory scene (industrial use). For example, for crocoite, we employed a picture of a blackened-in (dark color) crocodile (keyword for crocoite) playing with a baby (soft mineral) in a home scene (home use). The questions we wished to test, then, were: (a) Could learning disabled students make use of (i.e., correctly interpret) symbolized mineral attributes, rather than actual representational pictures? and (b) would LD students become confused with multiple instances of the same symbolized attribute (e.g., several baby pictures, or several factory scenes)?

To investigate these questions, we used a design similar to the ones used previously, with three conditions: mnemonic, rehearsal-based (with fast-paced questioning, feedback, and cumulative review), and free study. Not only did results parallel the findings of previous investigations, in that mnemonically instructed students substantially outperformed students in rehearsal-based and free study conditions, we also found that free study students performed statistically *higher* than students instructed with rehearsal-based methods! Our interpretation of this finding was that LD students, allowed to pace themselves, may have been better able to tie the information in some way to their prior knowledge system. Students in the experimenter-led rehearsal-based condition, on the other hand, may have been inhibited from elaborating the information, or in any way making the information more meaningful for themselves. In defense of rehearsal-based instruction, however, it should be acknowledged that our free study condition students were individually treated and closely monitored, as in the other conditions. This treatment should not in any way be interpreted as representative of the undesirable but all-too-prevalent condition found in resource rooms, in which students are given an individual folder of work sheets and asked to complete them in situa-

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tions in which the students are not closely monitored. Rehearsal-based methods may also be more effective when the information is more familiar to learners. These, however, are empirical questions, which await empirical investigation.

Visual-Spatial Displays. Two additional research studies, at least in part, followed from comments offered from anonymous reviewers of the research reports. From an anonymous reviewer's comments on a manuscript submitted for publication, we received the idea that a "visual-spatial display," of the type proposed by Engelmann and Carnine (1982) and in which relationships among individual facts are highlighted spatially, would provide a superior control condition. In response to this concern, we conducted a two-experiment investigation in which visual-spatial displays replaced the rehearsal-based condition (Scruggs, Mastropieri, Levin, McLoone, Gaffney, & Prater, 1985). In the second experiment, we also examined elementary-age LD students. In both experiements, mnemonic condition subjects substantially outperformed comparison condition students, including those in the visual-spatial display conditions. In these experiments, the visual-spatial display conditions were neither superior nor inferior to free study conditions in promoting learning.

In response to a reviewer's comments on this manuscript that cells we used in the visual-spatial display conditions should have contained pictures of the phenomena (minerals) being studied, we, as part of a larger investigation described later, created a visual-spatial display condition in which the cells did contain pictures of the content elements (dinosaurs). Again, mnemonic condition students far outperformed students using visual-spatial displays (Veit, Scruggs, & Mastropieri, 1986). We concluded that such spatial organizing strategies were not effective for facilitating the acquisition of unfamiliar content; however, it is possible that such spatial organization is potentially valuable in other contexts, for example, when relationships among previously learned concepts are being taught. Again, such questions are empirical.

GROUP IMPLEMENTATIONS

The results of the investigations described above suggested that mnemonic instruction could result in impressive learning gains, as compared with several comparison conditions. On the tasks we had employed, mnemonic instruction seemed to be very effective, at least when treatment was implemented individually in single treatment sessions. A question that could be logically derived from these results was whether mnemonic instruction would be similarly effective when students were taught in small groups and more than one mnemonic lesson was employed.

Minerals

We initially addressed these questions in two experiments. In one experiment Mastropieri, Scruggs, and Levin (1986, Exp. 1) taught hardness levels of minerals to 56 learning disabled secondary-age students in 12 instructional groups. Since

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groups, rather than individuals, were assigned at random to one of two treatment conditions, the mean group score, rather than the individual subject score, constituted the "unit of analysis" for the experiment (Hopkins, 1982). The use of the group score also helped maintain the assumption of independence of observations, a necessary requisite for statistical analysis. That is, in a single experimental session, any disruption or irregularity that may occur could be expected to impact upon all subjects in the group, rather than one individual subject. The use of a group mean rather than individual scores, therefore, helped assure independence of the data. Concerns for the sharply reduced number of observations (from 56 down to 12) are mitigated by our concomitant reduction in experimental groups (from three to two) as well as the virtual certainty that group mean scores will exhibit far less within-condition variability than independent subject scores, due to the fact that individual "outliers" will be absorbed within each instructional group mean. This decreased variability also increased statistical precision and compensated to a large extent for the reduction in the number of observations (for another alternative, the use of subjects as a nested factor within instructional groups, see Hopkins, 1982). In this case, analysis of the data indicated that mnemonic instruction had resulted in far greater recall than had experimenter-led rehearsal with fast pace, choral responding, immediate feedback, and cumulative review. Although the experimental task and the single instructional session had not changed, the use of groups for instruction provided an important extension that allowed us to design more applied research studies.

Dinosaurs

Veit et al. (1986) extended this research by employing, in addition to small group instruction, three separate lessons taught over 3 days. In this case, we designed three separate and independent lessons on prehistoric reptiles that were taught over 3 days of instruction. One lesson was concerned with the meanings of dinosaur names; another addressed attributes of dinosaurs (eating habits, geologic period, and an attribute particular to each dinosaur); and another lesson taught a list of hypothesized reasons for dinosaur extinction. The order of these lessons was counterbalanced (i.e., an equal number of students received each lesson in a different order) so that the test scores for each lesson could be compared without concern for any differential "practice" effects. We also wished to combine, for each condition, scores across the first, second, and third day of intruction to determine whether, accounting for possible lesson difficulty effects, performance changed tangibly over time. It could be argued, for example, that mnemonically instructed students could begin to catch on after a day or two of mnemonic instruction, and therefore begin to exhibit greater performance gains. On the other hand, it was possible that effects would begin to diminish over time, as students became confused by the presentation of too many mnemonic elaborations.

In this case, as in the previously described investigation, we assigned at random 24 instructional groups of LD students to mnemonic and control conditions. For the vocabulary lesson, the mnemonic condition students were taught parts of dinosaur names (e.g., *ptero-* = "winged", *saur* = "lizard") using the keyword method; control condition students were taught using drill-and-practice proce-

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dures, as in the group-implemented minerals study. After learning the word parts, students were tested on their ability to comprehend these word parts in novel (for the learners) combinations (e.g., ptero/saur = "winged lizard"). For the attribute lesson, mnemonic condition students were taught using procedures similar to those of the mineral studies, while the control condition students used a visual-spatial display, described above. Additionally, in the mnemonic condition we tested whether color could be used symbolically, to represent meat-eater (red) or plant-eater (green), as well as using color literally as before. For the extinction lesson, we used pegword-only strategy to teach possible reasons offered for dinosaur extinction in order of plausibility. For example, for reason number 4, that small mammals may have destroyed and eaten dinosaur eggs, we showed a picture of small mammals breaking and eating dinosaur eggs on a door (pegword for 4). Students in the control condition were shown a similar picture (without the door and accompanying strategy information) and given drill-and-practice similar to the vocabulary lesson. After each day, students were given a test of their immediate recall; on the fourth day, all students were given a cumulative recall test of all information covered.

Results. Results indicated that mnemonically instructed students substantially outperformed control condition students on all daily measures, as well as on the delayed recall measure. They also showed no overall decrease (or increase) in learning over time. In addition, in the vocabulary lesson, mnemonically instructed students were more able to apply learned information to novel contexts, in this case, the translation of novel dinosaur names from previously learned word parts. In addition to replicating the effects of the group-administered treatment, this investigation pursued two commonly raised concerns regarding mnemonic instruction: (a) Is mnemonically learned information comprehensible? and (b) can students be instructed mnemonically over several days without becoming confused? The Veit et al. (1986) investigation provided positive preliminary support for both these questions.

Limitations. Although this investigation maintained most of the experimental rigor of the previous investigations, it still did not model actual classroom conditions of instruction. First, the materials were chosen by researchers interested in validating certain types of mnemonic systems, rather than by curriculum specialists interested in the content to be conveyed. Second, we assured independence of content so that we could counterbalance presentation order to more effectively evaluate the cumulative effect of mnemonic instruction, without any potential interference from relative lesson difficulty. This means that no content overlapped, even to the extent that no specific dinosaur mentioned in one lesson would be mentioned in any other lesson. Such nonoverlapping content, while serving an experimental purpose, is unlikely to occur in any school situation. Additionally, all presentations were scripted and timed exactly for pace of instruction, a condition unlikely to be met in real school situations. Finally, the lessons were delivered by experimenters, rather than regularly assigned teachers. Nevertheless, the Veit et al. (1986) investigation provided the most "ecologically valid" infor-

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mation to date, and provided important information for us to use in designing and implementing future investigations that would take into account actual classroom conditions.

VOCABULARY EXTENSIONS

Training

Concurrent with the investigations studying content acquisition, we conducted a series of experiments involving vocabulary acquisition of mildly handicapped learners. In these experiments, in which students again were randomly assigned and individually taught in single instructional sessions, we investigated several issues of relevance to mnemonic instruction. In an initial vocabulary investigation, Scruggs, Mastropieri, and Levin (1985) taught concrete vocabulary words to 20 mildly mentally handicapped students. Because of the relatively small sample size, we used a crossover design, in which each student was taught 10 vocabulary words mnemonically and 10 vocabulary words via rehearsal based instruction. We developed both the mnemonic and rehearsal based materials for all 20 words, however, and alternated sets of materials so that the actual information taught did not vary as a function of condition and relative word list difficulty could not be a factor in the outcome. Likewise, we alternated treatment orders, so that half of the students received mnemonic instruction first, while the other half received rehearsal-based instruction first. This was done to eliminate concerns that the first (or second) presentation would result in differential performance, regardless of condition.

We also employed, for this investigation, low-frequency vocabulary words from a Scrabble dictionary, to eliminate prior knowledge concerns (e.g., *bugsha* = money; *dogbane* = tropical plant; *peavey* = hook). We also selected words that easily lent themselves to keyword reconstructions (*bugsha* = bug; *dogbane* = dog; *peavey* = pea), as we intended this to be a test of the keyword method under ideal conditions. We found, in fact, that under these conditions students recalled far more vocabulary definitions when instructed mnemonically than when experimenter led rehearsal was used.

Independent Strategy Generation

In another vocabulary investigation (Mastropieri, Scruggs, Levin, Gaffney, & McLoone, 1985), we examined, in Experiment 1, whether LD students could be effectively taught vocabulary (the same materials as in the previously described investigation) via the keyword method and, in Experiment 2, whether another sample of LD students could effectively generate their own mnemonic images, given verbal descriptions of vocabulary words, keywords, and definitions. Experimenter-led rehearsal served as the control condition in both experiments. Results indicated that the keyword method was a very effective treatment for initial vocabulary acquisition and that LD students could, given keywords and definitions, generate their own interactive images, to the extent that they still significantly outperformed their control counterparts, but not by as wide a margin as when

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they were provided with interactive mnemonic pictures. This finding provided promise that students, under some circumstances, could learn to generate their own mnemonic strategies.

We tested this hypothesis in a study by McLoone, Scruggs, Mastropieri, and Zucker (1986), in which students were directly taught a list of English or Italian vocabulary words and then trained to create their own keywords and interactive images on the other list. (We counterbalanced English and Italian words across learning and transfer tasks so the two tasks would be of similar difficulty.) Again, we found that the superior effect of keyword instruction was manifested even when students were trained to create their own mnemonic keywords and interactive images. We were, however, reluctant to assert that students could easily transfer keyword-type mnemonic strategies, in that the task we employed was experimental and the ability of LD students to transfer this method in actual classroom situations was, to this point, unstudied.

Concrete Versus Abstract Words

In a third vocabulary study (Mastropieri, Scruggs, & Fulk, in press), we addressed three additional research questions: (a) Could LD students benefit from keyword vocabulary instruction when vocabulary was not selected for keyword "obviousness?" (b) could LD students learn abstract as well as concrete vocabulary with the keyword method? and (c) does mnemonic instruction inhibit comprehension in any way? Impetus for this investigation came from a study by Johnson, Adams, and Bruning (1985), who provided evidence that college undergraduates studying "difficult" vocabulary words remembered mnemonically instructed concrete vocabulary, but did not recall mnemonically instructed abstract vocabulary any better than students had under free study conditions. We decided to test their conclusion, that the keyword method was ineffective for difficult abstract vocabulary words, with a sample of learning disabled students. In this investigation, we employed a mnemonic condition and a rehearsal-based control condition. We adapted the words of Johnson et al. (1985) using our own mnemonic and control pictures. To test whether our students would also comprehend the information, we devised a comprehension task, in which students were required to identify the target word when used in a context separate from that in which it was taught. The vocabulary words used by Johnson et al. (1985) were difficult (e.g., *catafalque, saprophytic, intercalate*) and had not been selected for keyword obviousness. We felt certain that if we could teach these words mnemonically to junior high-age LD students, we could teach virtually any vocabulary words to similar students.

Again, the results supported the effectiveness of mnemonic instruction. Not only did the mnemonically instructed students outperform the rehearsal-condition students on recall of both abstract and concrete information, they also exhibited a substantial performance advantage on the comprehension task. The results of this investigation supported the notion that mnemonic instruction is effective for more ecologically valid (less contrived) content and facilitates, rather than diminishes, comprehension.

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PROSE ADAPTATIONS

Prior to large scale implementations of mnemonic instruction, which would involve workbooks and other classroom materials, we believed that we should evaluate the ability of LD students to benefit independently from mnemonic illustrations and strategy information embedded within textual material. In other words, would the previous effects of mnemonic instruction of lists of vocabulary and factual information still be realized when this information was embedded within textbooks that students read for themselves? We investigated this issue in two research studies, involving three experiments. Scruggs, Mastropieri, McLoone, Levin, and Morrison (1987), in two experiments, developed mnemonic textbooks that provided both content and strategic information about mineral dichotomies (Exp. 1) and specific mineral attributes (Exp. 2). Control condition students read the identical passages, without specific strategy information and with representative, rather than mnemonic, pictures. In both experiments, students who read mnemonic materials significantly outperformed students who read control materials; in Experiment 1, the mnemonic condition advantage was still evident after a 1-week delayed recall interval. Furthermore, in Experiment 2, students who read mnemonic materials describing specific mineral information were more able than control condition students to infer attribute dichotomies. This latter finding provided further support that mnemonically instructed students comprehend better, as well as recall more, than students instructed by other methods.

In a second investigation (Mastropieri, Scruggs, & Levin, 1987a), we embedded mnemonic pegword illustrations relevant to ordered reasons for dinosaur extinction within textbook passages. In this experiment, we employed three conditions: mnemonic picture, picture control, and no picture control. We found that the representative picture control materials improved learning over the levels obtained by students in the no-picture condition; however, only students in the mnemonic picture condition were able to accurately recall reasons for dinosaur extinction with respect to their rated order of plausibility.

These two studies led us to believe that material development for classroom instruction was possible, in that students had independently benefited from text-embedded mnemonic strategies. We next turned our attention to a careful evaluation of the interaction of mnemonic strategies with the predetermined content of specific curriculum materials.

CLASSROOM APPLICATIONS

At this point in our research, we began to feel confident that mnemonic strategies were potentially very powerful facilitators for students characterized as LD or mildly mentally handicapped. Over several laboratory-type investigations, we had found that such strategies resulted in consistently and substantially higher levels of performance than rehearsal-based instructional routines, on immediate as well as delayed recall measures. Furthermore, we found that several related pieces of information could be presented within a single mnemonic picture, and that this information could be represented literally, symbolically, or acoustically

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with keywords or pegwords). We also found that color could be used to represent or symbolize information, and that mnemonic pictures and strategies could be embedded within textbook-like reading materials. Also, we had seen that mnemonic instruction facilitates comprehension as well as recall, and that it could be implemented with small groups as well as individual subjects, and over several administration periods, without any observable negative effects from interference from previously learned mnemonic systems.

During this research program, had any of our specific research questions resulted in negative or equivocal effects, we would have felt the necessity to revise our materials and/or procedures and conduct additional research in that particular area. The reason these studies consistently supported mnemonic strategy instruction was partly due to the extraordinary power of these strategies, and partly due to the fact that we chose to conduct a series of investigations, in which each new investigation represented only a small departure from the previous investigation. Each successful investigation, then, provided us with additional information, which we were able to incorporate in the next investigation to increase the probability of success. We also felt that, taken together, a substantial number of replications would offer a more convincing case for the power of mnemonic instruction than would, for example, one very large-scale investigation, in which several different variables were interacting simultaneously.

Textbook Analysis

With this body of research studies completed, we were close to attempting broad-based classroom applications of mnemonic instruction. The next step we took, then, was to evaluate actual classroom curricular materials with respect to their potential for mnemonic adaptation. The content we first examined was U.S. history during World War I. We decided to evaluate social studies before more conceptually difficult curricula such as science; we chose World War I because, if our adaptations proved to be effective, we wished to implement these materials during the second half of the year, and therefore wanted a content unlikely to have been covered in class by then.

The first thing we found in our textbook analysis was that not all information lent itself to keyword- or pegword-type reconstructions. In attempting to uncover the reasons for this, we discovered that keyword-appropriateness was largely determined by the variables of *concreteness* and *meaningfulness* (or familiarity). That is, keyword reconstructions were most appropriate when information was nonmeaningful to learners. As we had argued previously, "the recoding component of the keyword method serves to transform unfamiliar, nonmeaningful stimuli into more meaningful entities" (Mastropieri, Scruggs, & Levin, 1985a, p. 40). But what about information that was already familiar to learners? Such familiar information could include conditions of life at particular historical periods and specific attributes of new inventions or weapons of war. In addition, we determined that familiar information could be either *concrete* or *abstract*. If information to be learned is both familiar and concrete, it could easily be pictured in a representative (or *mimetic*) drawing. However, abstract information, even though familiar to learners,

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could be difficult to picture. Such information could include such abstractions as justice, religion, Republicans, or U.S. policy. In cases such as these, it does not seem appropriate to establish semantically irrelevant retrieval links (e.g., with keywords) when it may be possible to build on the underlying meaningfulness of the information. In these cases, then, *symbolic* reconstructions of the information can be made, substituting symbols such as scales, church, donkeys, or Uncle Sam, respectively, for the abstract concepts mentioned above. We had also found, from previous research, that attributes such as carnivore and hard/soft dichotomies could be effectively symbolized.

Reconstructive Elaborations

We therefore used this system of mimetic, symbolic, and acoustic (keyword) reconstructions to adapt the most important content covered in the relevant textbook chapters on U.S. involvement in World War I. Including a keyword-embedded first-letter strategy for learning lists of information (e.g., countries of the Central Powers), we referred to the entire model as "reconstructive elaborations" (Mastropieri & Scruggs, 1989c, 1989d). We evaluated its effectiveness by using these and picture-control materials to teach 31 important facts and concepts relevant to World War I (in 28 minutes of instruction) to 30 mildly handicapped high school students, individually, in a single session (Scruggs & Mastropieri, 1989c). We found that students who had been instructed via the reconstructive elaborations methods and materials learned nearly twice as much information as those taught using the picture control materials. We also found that all elements of the model—mimetic, symbolic, acoustic, first letter—resulted in significantly higher scores than did control presentations of the same information and maintained a significant advantage over a 3- to 4-day delayed recall interval. The results of this investigation underlined the value of an overall model of elaborative strategies in special education and paved the way for research implementations.

CLASSROOM IMPLEMENTATIONS

Design Considerations

Having determined that the materials themselves were effective in promoting learning and retention, we were ready to attempt classroom implementations of these mnemonic methods and materials. In conducting such classroom-based research, some experimental control will almost certainly be lost. Under actual classroom circumstances, instruction may not always be delivered precisely as intended, subject attrition or interference can inhibit research findings, random assignment to treatment conditions can be difficult or impossible, and classroom factors, such as teacher variables, peer interactions, or time of day constraints, can seriously compromise the validity of study outcomes.

Classroom-based research is not only more expensive in time and resources to implement, it is more difficult to monitor. An ideal research design involves the random assignment of perhaps 10 to 20 classrooms per condition to treatment conditions and the use of each classroom mean score (or subject scores treated

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as nested effects) as the appropriate unit of analysis. Such a design could effectively control for classroom effects, teacher effects, and nonindependence of data resulting from treating each student as the appropriate experimental unit. Such designs, however, are extremely difficult to set up and monitor. Even if sufficient resources are available to conduct such research, the difficulties inherent in monitoring fidelity of implementation will likely result in a loss of experimental control that will more than compensate for any statistical advantages gained from the design.

Nevertheless, researchers should strive to avoid the type of classroom x treatment confounding that results from assigning a small number of classrooms (e.g., one per treatment) to treatments and treating each student in each classroom as an independent unit. We have attempted to address these problems with the use of within-subject designs, in which each student receives each treatment, in counterbalanced order, and therefore serves as his or her own experimental control.

For classroom research implementation studies, then, design considerations should be different from those described for laboratory-type experiments. These considerations should include the following:

1. Base classroom research as literally as possible on previously conducted laboratory-type research with very rigorous experimental designs. If findings of classroom applications replicate previous experimentally rigorous laboratory-type studies, they will be less susceptible to question.
2. Use several, rather than one, classrooms, to eliminate, as much as possible, effects due to particular classroom factors.
3. When random assignment is not possible (and it very frequently is not), within-subject designs can be very effective alternatives. In addition, within-subject designs are more powerful statistically, and better protect against attrition effects. Each subject is his or her own control, so that when subject attrition occurs, it cannot differentially affect experimental conditions. "Carryover" or transfer effects are potential problems with these designs, but can be directly assessed with careful planning of treatment orders and strategy questioning.
4. Potentially confounding variables such as treatment order or chapter difficulty can be addressed in within-subject designs by counterbalancing such factors across classrooms.
5. Many replications of classroom-implementation research studies should be planned, as a number of replications will help establish the validity of findings.

RESULTS

We first implemented classroom-based mnemonic instruction in three junior high school self-contained classrooms, in a within-subject design (Scruggs & Mastropieri, 1989b). In this design, students received the World War I chapter mnemonically, the Roaring 20s chapter traditionally, the Depression-era chapter mnemonically, and the World War II chapter traditionally, in an A-B-A-B-type

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design. Analysis of the results indicated that students learned far more information when instructed mnemonically. Furthermore, average weekly grades, D+s under traditional instruction, increased to Bs under mnemonic instruction.

One limitation of this study was the fact that some chapters were taught mnemonically while others were not. Such a limitation leaves open the alternative explanation that the World War I and Depression chapters were simply easier chapters than were the Roaring 20s and World War II chapters. Although such an explanation seems unlikely in light of the volume of previous research, it nonetheless needed to be addressed. We planned an additional experiment (Mastropieri & Scruggs, 1988), in which each of four classrooms received different mnemonic and traditional chapters, in a different order. Each chapter was covered over a period of 2 weeks. Classroom 1 received instruction in order A-B-A-B (in which A = traditional instruction and B = mnemonic instruction); classroom 2 received order B-A-B-A; classroom 3 received order A-A-A-B; and classroom 4 received order B-B-B-A. In classroom 4, we wished to test additionally whether we would observe any spontaneous transfer of mnemonic strategies after 6 weeks of mnemonic instruction.

Results replicated the findings from the previous U.S. history investigation, in that students when instructed mnemonically scored much higher on tests, including recall tests of up to 8 weeks of instruction, than when they were instructed traditionally. Additionally, teachers rated mnemonic instruction as significantly more appropriate for LD students, and students also strongly favored the mnemonic condition.

Findings of the Mastropieri and Scruggs (1988) investigation have since been replicated and extended, using similar within-subject, "crossover" research designs and content from state (Indiana) history (Mastropieri & Scruggs, 1989b), as well as science content (Scruggs & Mastropieri, 1989b). In a separate investigation, Mastropieri, Emerick, and Scruggs (1988) employed teacher-constructed materials, which included stick figures and cutouts from magazines, to test whether such teacher-made materials could also be effective. In all investigations, it was found that mnemonic instruction resulted in far greater levels of achievement than did more traditional teacher presentations.

Transfer

In a set of experiments (Scruggs, Mastropieri, Jorgensen, & Monson, 1986; Scruggs & Mastropieri, 1988), we had found that highly able (gifted) students could spontaneously (i.e., without training) transfer mnemonic strategies to novel tasks, with little or no prompting. Normally achieving students, under the same set of conditions, were much less successful at transferring the strategy. Furthermore, our implementation studies had demonstrated that spontaneous transfer did not occur with LD students, even after 6 weeks of mnemonic teaching of similar content. Clearly, if LD students were to begin to use mnemonic strategies independently, specialized training procedures would be necessary.

We had previously addressed the issue of student transfer of mnemonic techniques to independent learning (Mastropieri, Scruggs, Levin, Gaffney, & McLoone,

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1986; McLoone et al., 1986); however, we had not attempted it previously in an implementation study. Scruggs and Mastropieri (1989a), after implementing 4 weeks of mnemonic instruction in life and earth science, taught an additional chapter in earth science using a procedure whereby mnemonic strategies were generated collectively by the class. Students then drew the mnemonic illustrations in their workbooks. Although overall level of recall of these student-generated mnemonics was very high, it was also found that less than half the content was covered under this condition, as compared with teacher-provided mnemonic units. We concluded that mildly handicapped students could generate their own mnemonic strategies, and that these strategies were very effective, on the whole. However, we argued that, given the extra time necessary for students to generate such complex strategies, teachers must decide whether the *content* or the *strategy* is of the most importance in specific teaching situations. If the strategy is more important than the content being used to teach the strategy, then such strategy training is justifiable. If, on the other hand, the content in question is of the most importance, then teacher-provided mnemonics should probably be employed.

INDEPENDENT REPLICATIONS

In addition to the work described above, a number of additional research studies have been conducted by others that have made substantial contributions to the area of mnemonic strategy instructional research. To our knowledge, all of these investigations have been based on doctoral dissertation research. Such research investigations are important not only to answer additional research questions, but also to provide important external validity to the work of other researchers. For instance, a specific instructional technique may be found to be generally effective, but effective only when certain individuals conduct the research. Such a finding would suggest that some perhaps unstated component of the success of the research is strongly tied to the individuals conducting the research. This would therefore strongly limit the external validity of the findings. On the other hand, work from one researcher or group of researchers that is replicated by independent researchers strongly argues for the external validity of that research.

Mnemonic instructional research in special education has very recently been conducted by researchers working independently from the present authors (Lautenberg, 1985, reported in Lautenberg & Scruggs, 1986; McLoone, 1985; and Tolfa-Veit, 1985, were also dissertations but were not conducted independently of the present authors). To our knowledge, all of these dissertations have supported our findings regarding the powerful learning effects produced by these strategies. Taylor (1981) conducted an initial vocabulary study in which keyword-instructed LD students far outperformed controls; however, the provision of the keyword to mnemonic condition students during testing provided an unfair prompt to the experimental condition. Berry (1986) provided less equivocal support for keyword-based vocabulary instruction, in that unprompted LD students who were instructed mnemonically far outperformed controls in each of two experiments. Yuen (1985) provided evidence mildly mentally handicapped students could be taught abstract vocabulary with the keyword method, although his results were somewhat obscured

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by floor effects, perhaps as a result of insufficient instructional time. Condus (Condus, 1984, reported in Condus, Marshall, & Miller, 1986) demonstrated that keyword vocabulary instruction was very effective when implemented in LD classroom settings over 5 weeks of instruction; Powell-Brown (1989) reported that keyword vocabulary instruction resulted in higher levels of LD students' learning and recall than a "semantic mapping" condition; and King (1989) provided additional support that LD students could use keyword strategies in learning content-area terminology. These six dissertations, taken together, provide independent support for the positive effects of keyword vocabulary instruction.

Additionally, dissertations by Willott (1982) and Greene (1988) have investigated the use of pegword strategies to facilitate the learning of multiplication tables. Using somewhat different strategies, both reported that mnemonic instruction had promoted more efficient acquisition of math facts.

Altogether, the results of these eight dissertations suggest that few, if any, "researcher effects" exist in the line of research we have described. Taken with our approximately two dozen studies, we believe that the previous potential of mnemonic instruction has become a present reality.

THE FUTURE

To date, we have found that mnemonic instructional methods and materials, both teacher- and researcher-developed, can produce dramatic gains in classroom learning for special education students. (For support of our claim that these are the *most* effective strategies ever experimentally investigated in special education, see Mastropieri & Scruggs, 1989a.) In spite of the quantity of research to date on the use of mnemonic techniques in special education, there is still a great deal of research to be conducted. Mnemonic instruction of the type similar to that described here could help facilitate the acquisition of basic skills, such as phonics (Ehri, Detfner, & Wilce, 1984) and spelling and mathmetics operations, perhaps using the "Yodai" method (Machida & Carlson, 1984). Whether or not such strategies are helpful, however, awaits further research. Likewise, further research on the independent transfer of mnemonic strategies remains to be completed. Again, any such research should parallel the development we have described here: Specific strategies should be validated in laboratory-like settings and, if effective, evaluated again in small group and then in classroom presentations. As such research evolves, the designs and materials used in these studies should also evolve.

CONCLUSIONS

We have described, from our own experience, a model for experimentally validating special educational methods and materials. We have argued that the research should be firmly grounded in theories of learning and instruction, as well as theories of specific disability areas. Initial research, testing the potential of such strategies under optimal experimental circumstances, provides a necessary first step in validating and refining the specific instructional strategies (for another opinion, see Shepherd & Gelzheiser, 1987, and Pressley, Scruggs, & Mastropieri, in press, for our response).

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Once strategies have been thoroughly tested in one-to-one laboratory situations, using a number of strategy variations, they should be tested in small group situations, as well as independent learning situations. Additional content adaptations should be tested, including investigations of the effects of repeated strategy presentations. If such investigations are positive with respect to the strategy being studied, applications in "real" classroom settings are necessary to provide external validity. Throughout this program of research, we have argued that small, replicated extensions, conducted frequently over time, provide the greatest overall support for the strategies. Replications by independent researchers are also critical to establish the overall value of these strategies. The final step in any research program is for individual teachers to validate the strategies in their own classrooms, using formative evaluation techniques (Mastropieri & Scruggs, 1987).

After 8 years of mnemonic research, we feel sufficiently confident in the power of these methods to recommend their use by special education teachers. As a result, we have recently completed a book (Mastropieri & Scruggs, in press) in which we attempted to describe, for teachers, precisely how such strategies can be developed in a variety of classroom applications. Nevertheless, we believe that the use of mnemonics is limited to the continuing empirical support for the techniques in the research literature. We hope to play a role in contributing to this future research support.

Authors' Note

Preparation of this manuscript was supported in part by grants (Nos. [illegible] and [illegible]) from the U.S. Department of Education, Special Education Programs.

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ERRATUM

The art for Figures 1 and 2 was reversed in "Use of Constant Time Delay in Small Group Instruction: A Study of Observational and Incidental Learning," by Patricia Munson Doyle, David L. Gast, Mark Wolery, Melinda Jones Ault, and Jacqueline A. Farmer, JSE 23:3, pp. 379 and 381. The publisher regrets this error.

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Appendix R

Scruggs, T.E., & Mastropieri, M.A. (1990b). Mnemonic instruction for learning disabled students: What it is and what it does. Learning Disability Quarterly, 13, 271-280.

MNEMONIC INSTRUCTION FOR STUDENTS WITH LEARNING DISABILITIES: WHAT IT IS AND WHAT IT DOES

Thomas E. Scruggs and Margo A. Mastropieri

***Abstract.* One of the characteristics of learning disabled (LD) students most commonly mentioned by teachers and researchers is difficulty with semantic memory. Recently, an instructional model has been developed, referred to as *mnemonic instruction*, which is directly targeted to learners with difficulties in semantic memory. This article describes the concept of mnemonic instruction and how it interacts with the specific learning characteristics of LD students. Additionally, the extraordinary effectiveness of the techniques with LD students, as reported in numerous published research studies, is described. Implications for classroom instruction and further research are provided.**

One of the most commonly described characteristics of learning disabled (LD) students is their failure to remember important information. In addition to frequent reports by teachers of LD students, this characteristic has often been demonstrated in experimental research (e.g., Cooney & Swanson, 1987).

Previously considered only one in a cluster of deficits that limit the achievement of LD students (e.g., Kirk & Kirk, 1971), deficits in memory, particularly with respect to recall of semantically based information, have come to be regarded by many researchers as a central characteristic of learning disabilities (see Swanson, 1987). These deficits contribute in many cases to problems in reading and math and acquisition of academic vocabulary and content (e.g., Kail & Leonard, 1986). It could be argued, therefore, that intervention strategies that specifically target these memory deficits could be expected to prove beneficial in the education of LD students. Recently, such techniques, referred to as "mnemonic instruction," have been implemented with learning disabled students with very positive results.

In this article, we describe what mnemonic instruction *is*, and how it interacts with specific characteristics of learning disabilities. We also describe what mnemonic instruction *does*—that is, what gains have been documented in specific instances of school learning. Further, we argue (and provide evidence) that mnemonic instruction delivers the greatest learning increases seen in the history of learning disabilities intervention research. Finally, we describe implications for classroom practice and further research.

WHAT MNEMONIC INSTRUCTION IS

A "mnemonic" is a device, procedure, or operation that is used to improve memory. Defined in such broad terms, however, virtually any instructional practice could be defined as "mnemonic." So this definition—while correct—is not particularly useful. What we mean by "mnemonic" in this article is a specific reconstruction of target content intended to tie new information

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more closely to the learner's existing knowledge base and, therefore, facilitate retrieval. A variety of techniques have been developed for this purpose (described below), including keywords, pegwords, acronyms, loci methods, spelling mnemonics, phonetic mnemonics, number-sound mnemonics, and Japanese "Yodai" methods.

History of Mnemonics

Mnemonics have been used for thousands of years. The first documented use was among ancient Greeks, who, having limited access to writing materials, developed complex mnemonic systems for remembering stories, poems, plays, and lectures (see Yates, 1966, for a comprehensive discussion of the history of mnemonics). A common technique for storing and recalling narrative or lecture information was the "method of loci," attributed to the poet Simonides, who first employed the technique to identify the bodies of persons who had been killed and disfigured after a banquet hall had collapsed on them.

The Greeks who wished to remember oral presentations first developed their own set of "loci," or places, with which they could associate information in sequence. For example, they developed these loci by spending many hours inside a temple (or other building) carefully memorizing ornaments, statues, and other places in the temple, in the particular spatial sequence in which they occurred. When they had thoroughly mastered this set of loci, to the extent that they had created a very familiar and easily retrievable image of the place, they used it as a framework to which they tied incoming information, in sequence. Then, as they listened to a lecture, they would tie each important point to a *locus*, or place, in their set of loci. For instance, if the first major point to recall was the issue of human mortality, and the first locus in the set was the steps leading to the temple, the mnemonic listener could, while listening, actively create an interactive visual image of a dead or dying person on the steps of the temple. If the image were carefully elaborated and visualized, learners later had little difficulty retrieving the image and the corresponding first point of the lecture.

This example underlines an essential feature of learning: the realization that, to be useful, information must be both comprehended *and* remembered. Therefore, when Ancient Greeks encountered new, important information, they actively encoded it into their memory system, as they listened for comprehension. These ancient arts are mostly lost today, as people rely (sometimes excessively) on notetaking and on the printed page. With little access to writing materials or books, the Ancient Greeks used strategies that did not require the use of pencils and books. Similar strategies have proven highly successful for learning disabled students of today, who have access to, but little skill in interpreting, written materials and books.

Many of the Ancient Greek techniques were revived in the Middle Ages, where they were sometimes associated with mysticism and the occult (Yates, 1966). However, with the invention and development of the printing press, the use of mnemonics, particularly the method of loci, became less popular. Around the turn of the 19th-20th centuries, a renewed interest in mnemonics began. For example, James (1890), in the first major psychology text, wrote of the "phoneme-digit" mnemonic for recalling strings of digits. However, during the behavioral era of psychology, mnemonic strategies were discounted as "unobservable."

Later, Miller, Galanter, and Pribram (1960) wrote of the "pegword" method of associating numbers with things, and in 1970, Bower described the usefulness of mnemonic strategies, such as the method of loci, and their legitimacy for psychological study.

Perhaps the greatest modern impetus for the study of mnemonics came in 1975, when Atkinson published an experimental study of the "keyword" method for teaching Russian vocabulary. Although keyword-type mnemonics were described by the Ancient Greeks, Atkinson's paper initiated a resurgence of interest in mnemonic strategies, partly because of the extraordinary versatility of the keyword method. The powerful potential of mnemonic strategies for school aged populations was soon recognized (Pressley, Levin, & Delaney, 1982), and research in mnemonic strategy use by learning disabled students began in earnest during the early 1980s.

Memory and Learning Disabilities

With the failure of earlier explanations of learning disabilities to yield effective remedial techniques (see Kavale & Forness, 1985), researchers began to uncover deficits in memory as characteristic of many LD students (e.g., Torgesen & Goldman, 1977; Torgesen & Houck, 1980; Torgesen & Kail, 1980). Other researchers have suggested that these memory deficits may be language based (Swanson, 1987; Vellutino & Scanlon, 1982). For example, Baker, Ceci, and Herrmann (1987) reviewed evidence that learning disabled students exhibit problems in the *structure* (storing and organizing) as well as the *process* (operating on stored information) of semantic memory. Kail and Leonard (1986) described "word finding" problems of a subset of learning disabled students, attributed to inadequate representation of words in memory, in addition to other basic deficits in language-based information retrieval. Ceci (1985) presented research evidence that LD students exhibit greater deficits on purposive, rather than automatic, semantic processing, and recommended,

> instead of advocating intervention plans that are directed at remediating alleged cerebral insult or dysfunction, a more profitable approach to children with semantic processing difficulties . . . is to train purposive information-processing strategies like elaborative encoding, clunking, anticipation, type 2 rehearsal, and so on. (p. 219)

Such accumulated research evidence suggests strongly that interventions that are intended to impact directly on LD students' purposive semantic encoding and retrieval processes are likely to affect academic achievement positively. Mnemonic strategies, which directly provide such encoding and retrieval routes, have been found highly successful at improving LD students' semantic memory deficits. Although mnemonics have proven very helpful for many types of students (Pressley et al., 1982), mnemonic strategies appear to serve a particularly useful purpose in that they may interact directly with the disability area of many, if not most, LD students.

Types of Mnemonic Strategies

Loci methods have already been described. Other mnemonic strategies include the keyword method, the pegword method, acronyms, reconstructive elaborations, phonic mnemonics, spelling mnemonics, number-sound mnemonics, and the Japanese "Yodai" mnemonics for learning mathematics procedures. These mnemonic systems are too varied and complex for us to describe adequately in a single article. However, we will provide a brief summary. (For a complete description of all school-relevant mnemonic systems, see Mastropieri and Scruggs [in press].)

Keyword method. The keyword method employs acoustically similar keywords as meaningful proxies for unfamiliar words that must be learned. These keywords are presented in a picture in which they are shown interacting with the associated information. For example, to teach that *vituperation* means "abusive speech," learners are first given a keyword for vituperation, such as *viper*, which sounds like vituperation but is easily pictured, and shown an interactive picture, in this case, a viper speaking abusively. When asked to define "vituperation," learners retrieve the keyword, *viper*, remember the picture of the viper, retrieve what the viper was doing, and respond, "abusive speech" (see Mastropieri, 1988, for more examples).

Much of the early research with the keyword method involved vocabulary learning (e.g., Atkinson, 1975; Mastropieri, Scruggs, Levin, Gaffney, & McLoone, 1985); however, keywords can also be used to teach scientific root words (Veit, Scruggs, & Mastropieri, 1986), accomplishments of important people (Scruggs & Mastropieri, 1989), and complex scientific concepts, such as "radial symmetry" (Scruggs & Mastropieri, in press). In addition, keywords can be employed in teaching mathematics vocabulary, such as "multiplier," and "multiplicand."

Pegword method. This method employs rhyming pegwords (one is *bun*, two is *shoe*, etc.) to facilitate recall of numbered or ordered information, such as the first 10 amendments to the Constitution, or the order of admission of states to the United States. Pegwords also can be combined with keywords to link unfamiliar names with numbers. For example, to teach that the hardness level of the mineral *hornblende* (according to Moh's scale) is *five*, students can be shown a picture of a *horn* (keyword for hornblende) with a *hive* (pegword for five) in it. Therefore, when asked for the hardness level of hornblende, learners can think of the keyword, *horn*, think of the picture with the horn in it, remember that a hive was in the horn, and retrieve the number equivalent for the pegword *hive*, five (Mastropieri, Scruggs, & Levin, 1985). Pegwords have also been used to teach possible reasons for dinosaur extinction, ordered by relative plausibility (Mastropieri, Scruggs, & Levin, 1987), and to instruct LD students in multiplication facts (Willott, 1982). In the latter investigation, combinations of pegwords were used to represent higher numbers (e.g., fifty = "gifty," i.e., gift-wrapped, 6; = "sticks", therefore, fifty-six = "gifty sticks").

Acronyms. Acronyms are perhaps the most familiar mnemonics. Almost everyone has used the acronym *HOMES* to retrieve the names of the Great Lakes: *H*uron, *O*ntario, *M*ichigan, *E*rie, and *S*uperior. Such acronyms are helpful when a *set* of responses, rather than a single response, is required. Sometimes (but rarely) they can be used to represent information in order (e.g., *F-A-C-E* to retrieve the names of notes on the spaces in the treble clef). Kilpatrick (1985) reported the use of the acronym FOIL to retrieve the sequence of operations in multiplying two binomials. The product (a+b) (c+d) is the sum of the *F*irst terms (ac), the *O*uter terms (ad), the *I*nner terms (bc), and the *L*ast terms (bd). Information can also be re-ordered as an *acrostic* in which the first letters of words combine to facilitate retrieval (e.g., *E*very *G*ood *B*oy *D*eserves *F*udge, to retrieve the names of the notes on the lines of the treble clef).

For acronyms to work well, the *response* information should be sufficiently familiar so that retrieval can be easily accomplished by provision of the first letter. That is, students must be familiar enough with *Superior* that they can retrieve the name, given only the first letter. Additionally, acronyms work best when they are effectively elaborated with the stimulus information (e.g., a picture of *homes* on *great lakes* to prompt learners to retrieve the acronym when asked, "What are the names of the Great Lakes?"). For another example, Scruggs and Mastropieri (1989b) created the acronym *TAG* to refer to the countries in the Central Powers during World War I—*T*urkey, *A*ustria-Hungary, and *G*ermany. However, to ensure that learners would associate these countries with the Central, rather than the Allied, Powers, the game of tag was shown being played in Central Park (keyword for Central Powers).

Reconstructive elaborations. Scruggs and Mastropieri (1989) first described the model of "reconstructive elaboration" for adapting entire domains of content to mnemonic instruction, including U.S. history (Mastropieri & Scruggs, 1988; Scruggs & Mastropieri, 1989a); state history, including transportation and natural resources (Mastropieri & Scruggs, 1989b); and science content, including invertebrate animals, vertebrate animals, earth science, and earth history, (Scruggs & Mastropieri, in press). This model uses mnemonic elaborative systems based on the principle that the more *familiar*, *concrete*, and *well-elaborated* information is, the better it will be learned and remembered.

The reconstructive elaborations model employs keywords (acoustic reconstructions) for encoding unfamiliar information, symbolic pictures (symbolic reconstructions) for encoding familiar-but-abstract information, and literal pictures (mimetic reconstructions) for familiar, concrete information. Examples of keywords have been given above. An example of a symbol for familiar-abstract information could be *scales* for *liberty*, or a *church* for *religion*. Mimetic pictures for familiar, concrete information could include literal pictures of information such as *worms*, *birds*, or *pioneers*. All reconstructed target information is carefully elaborated pictorially with its referents. When appropriate, pegwords and acronyms are used. The reconstructive elaborations model is described in detail in Mastropieri and Scruggs (1989c).

Phonic mnemonics. Most of us remember seeing phonetic prompts in our classrooms consisting of a letter next to an object whose first sound is represented by that letter sound (e.g., the letter "a" next to a picture of an "apple"). Unfortunately, this arrangement is not truly "mnemonic," at least in the sense employed here, because the stimulus and its referent are not effectively elaborated. Ehri, Deffner, and Wilce (1984) described the effective use of phonic mnemonics, in which letters were incorporated *within* the item that represents the letter sound (e.g., an interactive picture in which the letter "a" is drawn to resemble an apple). Such mnemonics could be expected to greatly improve initial acquisition of sound-symbol relationships—a substantial problem for many LD students.

Spelling mnemonics. An important use of mnemonics lies in drawing firm associations in content or skill areas where the relationships are arbitrary. For example, in English the "schwa" sound—the most common vowel sound—is not represented by any one letter but may be represented by any given vowel. The word "cemetery," for example, could be spelled in a variety of ways that all capture the appropriate vowel sounds, but is spelled with three e's—a convention that must be remembered. An effective mnemonic elaboration, described by Shefter (1976), incorporates the three e's with the word in the elaborative sentence, "She screamed 'E-E-E' as she walked by the cemetery." Students who retrieve the sentence can remember the correct spelling of "cemetery."

Number-sound mnemonics. This type of mnemonics is used to recall strings of numbers, such as telephone numbers, addresses, zip codes, locker combinations, social security numbers, or historical dates. To use them, learners must first learn the number-sound relationships: 0=s; 1=t ; 2=n; 3=m; 4=r; 5=l; 6=sh, ch, or soft g; 7=k, hard c, or hard g; 8= f or v; and 9=p. Acquisition of these relationships can be facilitated by remembering the sentence, "Satan may relish coffee pie," in which the consonants represent the appropriate letter sounds, in the order 0-9. To encode a series of digits, therefore, the learner must first find the appropriate consonants, and then arrange vowels between the consonants to create a word or words that can be elaborated with the associated information. For instance, to remember the date 1492, the learner uses the associated consonant sounds, t, r, p, and n, and inserts vowels to create a meaningful word or words. In this case, "terrapin" could be used (there is only one r sound, even though two r's are represented in "terrapin"). An effective mnemonic picture or image could be constructed of Columbus discovering land, on which is a *terrapin* (1492).

A related type of mnemonic for retrieving types of digits involves associating number proxies (either pegwords or physically similar proxies, such as 0=tire, 1=pencil, etc.) with the *head*, *hand*, and *foot* of a *father*, *mother*, and *child*, respectively. Thus, the first number proxy would be presented on the *head* of the *father*, whereas the fifth number proxy would be placed on the *hand* of the *mother*. Such systems have facilitated digit-span recall in learning disabled students (Laufenberg & Scruggs, 1986).

"Yodai" methods. In Japan, schoolchildren are taught a variety of mathematical procedures using rhymes and visual imagery. Many of these mnemonics have employed bugs as visual images. Although little of this work has been translated into the English language and American culture, one aspect of Yodai mnemonics, involving swimming pools and joggers, has been described by Machida and Carlson (1984). One rhyme used is "POOL (i.e., put together) shirts (numerators) to shirts, patches (denominators) to patches." Students are shown a picture of a swimming pool in the shape of the multiplication symbol. A jogger, wearing shirt and shorts (with patches), is on each side. The numerator of a fraction is shown on each shirt, with the denominator on the patches. These Yodai methods are consistent with mnemonic principles by employing pictures or images of familiar things to promote learning and comprehension of new, unfamiliar information. With respect to LD students' deficits in semantic memory, it must be remembered that many mathematics tasks contain highly verbal components. In fact, on commonly used intelligence tests, the arithmetic subtest is included on the Verbal, rather than Performance, scale.

Summary

In this section, we have described the history of mnemonics and the potential of mnemonic strategies for students with learning disabilities, followed by a review of several school-relevant mnemonic systems. In the section that follows, we will discuss the extraordinary effectiveness of these strategies when employed with LD students.

WHAT MNEMONIC INSTRUCTION DOES

Over the past eight years, numerous research investigations have documented the effectiveness of mnemonic strategies with LD students, sufficient for us to discuss broadly the implications of mnemonic strategy instruction given in this section. (For a complete review of mnemonic instruction research in special education, see Scruggs and Mastropieri [1990].)

The Effectiveness of Mnemonic Instruction

Mastropieri and Scruggs (1989a) recently synthesized the results of 24 experimental investigations of mnemonic instruction in special education settings (21 of the experiments involved primarily LD students, while two involved mildly mentally handicapped students, and one behaviorally disordered students). Subjects included 983 mildly handicapped students, from grades 3 to 12, in four different states. Across all these experiments, students instructed mnemonically outperformed students instructed by a variety of control conditions, including free study; direct rehearsal, questioning and feedback; visual-spatial display conditions; and teacher-led "traditional" instruction employing the teacher-effectiveness variables (Mastropieri & Scruggs, 1987).

The overall effect size of these combined investigations was 1.62 standard deviation units, the highest measure of treatment effectiveness reported to date in a synthesis of special education research. An overall effect size of 1.62 means that an "average" mnemonic-instruction condition student (i.e., 50th percentile) scored at the 98th percentile of the control group. For comparison, Kavale and Forness (1985) reviewed previous quantitative syntheses of special education interventions, reporting overall effect sizes ranging from -0.12 to +0.58, for such interventions as reduced class size, special class placement, psycholinguistic training, perceptual-motor training, stimulant and psychotropic drugs, and diet interventions. In addition, in each of these cases, substantial negative effects (i.e., the control group outperformed the experimental group) were reported (see also Kavale, in press). In the synthesis of mnemonic-strategy instruction experiments, Mastropieri and Scruggs (1989a) reported that all effects were positive and substantial (range = 0.68 to 3.42).

Mastropieri and Scruggs (1989a) also synthesized these findings across experiments by computing the percent correct scored by students in mnemonic and combined control conditions. These analyses revealed that, on average, mnemonic-condition students learned 75.0% of the information presented, while control students learned only 43.8% of the information. As evidenced by this synthesis, the effects of mnemonic instruction are positive, consistent, and very large. Such information can make the difference between passing or failing in school; indeed, in one school, we found that mnemonic instruction improved average weekly grades of "D+" to weekly grades of "B" (Scruggs & Mastropieri, 1989a).

Effects on Recall

Most of the effects of mnemonic instruction reported to date involve recall of target information—the central objective of instruction designed to enhance memory. Thus, positive experimental effects have been documented for immediate learning and delayed recall intervals of 24 hours (Mastropieri, 1983); two to three days (Laufenberg & Scruggs, 1985; Veit, Scruggs, & Mastropieri, 1986); one week (Mastropieri, Emerick, & Scruggs, 1988; Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1987); eight weeks (Mastropieri & Scruggs, 1988); and 10 weeks (Condus, Marshall, & Miller, 1986).

Effects on Comprehension

Kilpatrick (1985), among others, has argued that, although students taught mnemonically are able to effectively retrieve information, they do not comprehend such information. Mnemonic instruction, according to this perspective, is merely a "trick" that enables learners to "parrot" back responses they do not understand. Of course, it is possible to memorize, mnemonically or otherwise, information one does not understand (e.g., E=MC^2). Conceivably, therefore, mnemonic instruction could be employed for this dubious purpose. However, such an argument suggests a relationship between memory and comprehension such that information that is "memorized" is not necessarily comprehended, while information that is comprehended is, *ipso facto*, remembered. This putative relationship is untrue; in fact, it has little or no empirical research support.

Most, if not all, teachers of LD students report that their students routinely forget information they had comprehended adequately the day before. Why does this occur? Although the information itself may be comprehended, the verbal label representing it may be a completely arbitrary arrangement of speech sounds that bears no semantic relation to the target information. For students with phonological coding or semantic processing disabilities (i.e., most LD students), the label is soon forgotten, and without access to the verbal label, students cannot retrieve, discuss, evaluate, or "comprehend" the original information. Those who accuse mnemonics of promoting parrot-like responses should be reminded that mnemonic systems impact directly on the *concreteness* and *meaningfulness* of target information, and should, therefore, *enhance*, rather than *detract from*, comprehension.

In addition to the above rational arguments that discredit "comprehension trade-off" views, empirical evidence suggests that mnemonic techniques actually enhance comprehension. Veit et al. (1986) mnemonically taught LD students Greek root words for dinosaur names (e.g., *ptero-*, meaning "winged," *saurus*, meaning "lizard"). The students not only remembered more of these root words than their rehearsal-instructed counterparts, they were substantially more effective at translating complete dinosaur names they had not seen before (e.g., *pterosaur*="winged lizard").

In another investigation, Scruggs et al. (1987) reported that, in addition to recalling more specific information about attributes of North American minerals (color, hardness, use) than their control condition counterparts, mnemonically instructed LD students were also significantly more effective at inferring untrained attribute dichotomies.

Recently, the comprehension question has been investigated directly. Mastropieri, Scruggs, and Fulk (1990) taught difficult abstract and concrete vocabulary words (e.g., *saprophytic*, *intercalate*, *catafalque*) to LD students via either mnemonic keyword instruction or a rehearsal-based picture control. Mnemonically instructed students outperformed controls on recall of both abstract and concrete vocabulary words. In addition, they significantly outperformed controls on a comprehension test of the words, in which learners were required to apply the words in a context different from that presented.

Given the above evidence, we can conclude that mnemonic instruction may be used to *facilitate*, rather than inhibit, comprehension. Although it is possible to remember information without comprehending it, such an outcome is by no means a foregone conclusion of mnemonic instruction. Furthermore, for many LD students, mnemonic instruction may represent the only realistic chance that they *will* comprehend specific academic content.

Metacognitive and Affective Outcomes

Some research studies have shown that LD students recognize the value of mnemonic instruction in enhancing their own learning. For example, in a study of the effects of text-embedded mnemonic pictures (Scruggs et al., 1987), LD students rated mnemonic pictures as significantly more helpful for promoting their own learning than traditional representational pictures of the same information. Similarly, in a recent classroom study of the effectiveness of mnemonic science instruction (Scruggs & Mastropieri, in press), students overwhelmingly preferred mnemonic to traditional teacher-led instruction, both in terms of enjoyment and educational value.

In addition to the empirical evidence outlined above, teachers employing mnemonic instruction frequently report that their students stay on task longer, participate more in class, and appear to enjoy learning more when participating in this type of instruction. The reason for this effect appears to be that LD students typically regard schoolwork as an endless series of memory tasks involving meaningless information, at which they are unlikely to succeed (Licht & Kistner, 1986). Mnemonic instruction, as we have employed it, involves presenting interactive cartoon-like pictures on overhead projectors that focus attention on target information and also provide direct retrieval links between information that must be learned and information that is concrete and familiar to students. When asked questions, then, students know how to go about retrieving the answer. These explicit retrieval steps can serve to create a sense of empowerment in students, who may begin to feel more responsible for their own learning.

Teacher Acceptance

Throughout our research, teachers have consistently reported their approval of, and enthusiasm for, mnemonic instructional methods and materials. In a recent investigation (Mastropieri & Scruggs, 1988), using a standardized instrument to measure the appropriateness of an intervention for target learners, teachers rated mnemonic instruction as significantly more appropriate for content-area teaching of LD students than traditional textbook-based methods.

Material Development

Mnemonic instruction has proven highly effective for promoting LD students' academic performance. However, mnemonic instructional materials are not available commercially for special education teachers—most of the materials used to date have been developed by researchers (often, with access to artists), specifically for their studies. Given the absence of commercial mnemonic instructional materials, what is the potential for teachers to develop mnemonic materials?

We must admit it takes time, energy, and resources to develop these materials, but we have seen some successful teacher applications—even among teachers who have little artistic ability. Mastropieri, Emerick, and Scruggs (1988) reported on an investigation of the effectiveness of mnemonic science instruction for which the teacher had developed her own materials. Rather than using professional line drawings, the teacher used stick figures and cutouts from magazines. With these materials, students taught mnemonically scored significantly higher than when taught using more traditional methods and materials. Students even increased their mnemonic advantage over a one-week delayed-recall interval. Likewise, Mastropieri, Whittaker, and Scruggs (1988) noted the success of teacher-developed mnemonic materials in teaching anatomy, while Mastropieri and Plummer (1988) reported on a mainstream high school teacher who was able to recruit the assistance of a student-artist to draw mnemonic pictures. These reports suggest that teacher development of mnemonic instructional materials, although perhaps difficult, is altogether possible.

Generalization

During our mnemonic instructional research, the question has frequently been asked, "Can LD students be trained to create and use mnemonic strategies independently"? If this goal could be achieved, not only would it be unnecessary to develop materials, but students would be able to use the strategies in any classroom or other setting where their use is appropriate. Although generalization is a desirable outcome, results of generalization studies have been equivocal. For example, McLoone, Scruggs, Mastropieri, and Zucker (1986) trained LD students to transfer the keyword method to another, highly similar list of vocabulary words. The words used (English and Italian vocabulary words), however, were simple, concrete words with relatively "obvious" keywords (e.g., dogbane, bugsha).

On more complex applications, generalization attempts have been less successful. Scruggs and Mastropieri (in press) trained LD students to generate mnemonic strategies as a group in an attempt to learn science content. Although the students developed and employed the strategies successfully, they moved through the content about one third as fast as when teachers provided the strategies. (The perception that students learn faster when strategies are provided is supported by teacher interviews reported by Pressley et al.—to appear in LDQ, Winter 1991.) Most recently, Fulk (1990) trained students individually to generate keyword-type mnemonics for a variety of content domains. After several days of training and guided practice, students were able to generalize effective mnemonic strategies on some, but not all, dependent measures.

Based on the results of mnemonic transfer research, (a) students can be trained to independently generate mnemonic strategies on simple transfer tasks involving simple keywords; (b) students can generate strategies on more complex tasks with teacher guidance at a sacrifice of content covered; and (c) on completely independent transfer tasks, students may exhibit great difficulty developing appropriate strategies. We have been rather pessimistic regarding the transfer potential of mnemonic strategy instruction, because, after eight years of experience, it still takes us a great deal of time and effort to create the strategies. In fact, often the proper strategies do not occur to us until several days after our first attempt. Therefore, it is likely that it will take even longer for LD students to create these complex strategies. For some tasks, teachers must choose between maximizing content learning or maximizing strategy learning (Mastropieri & Bakken, in press). Although educational researchers are often preoccupied by independent strategy use as a "higher level" goal, teachers tend to be concerned with more immediate goals, such as students passing tests and staying in school.

Nevertheless, we do believe that students can be taught about the effectiveness of mnemonic encoding, and that, in time, they can begin to apply at least some aspects of these strategies on their own. We have found that it can be helpful simply to attend to the *acoustic* properties of unfamiliar words—what the new word sounds like that is familiar to the student—even if these acoustic similarities are not effectively elaborated.

Finally, we believe that if teachers begin to practice mnemonic instruction, and use it consistently over a period of months, or even years, students will become more aware of the effectiveness and utility of these techniques, and will gain sufficient experiential background to begin using them independently. It is difficult to imagine successfully training students to use strategies that they do not see teachers use in their own teaching. With further research and development activities, and the emergence of consistent mnemonic teaching practices, including generalization and attribution training (e.g., Fulk, 1990), we believe that LD students can learn to transfer much of the essence of mnemonic instruction to their own learning.

Summary

We have provided evidence that mnemonic instructional strategies have produced some of the largest, most consistently positive outcomes in special education intervention research. Furthermore, we have maintained that mnemonic instruction impacts greatly on recall, comprehension, and affective outcomes. In addition, this instructional approach is highly regarded by both teachers and students, and teacher-developed materials have proven as successful as those developed by researchers. Finally, we have noted only limited success for student generalization of mnemonic strategies. However, we argue that with more intensive and lengthier teacher implementations, coupled with explicit generalization and attribution training, students may learn to incorporate at least some aspects of mnemonic techniques into their own learning.

CONCLUSION

Mnemonic techniques have been with us for thousands of years, but only recently have they been used to address the unique learning needs of students with learning disabilities. Techniques that are at least potentially useful to LD students include loci, keywords, pegwords, acronyms, reconstructive elaborations, phonic mnemonic, spelling mnemonics, number-sound mnemonics, and Yodai methods. When evaluated experimentally, these methods have produced very positive outcomes on the learning, comprehension, retention, and affect of learning disabled students. These powerful techniques are expected to result in greater implementation in special education settings in the near future.

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FOOTNOTES

Preparation of this manuscript was supported in part by a grant from the U.S. Department of Education, Special Education Programs, #GOO8730144.

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Appendix S

Scruggs, T.E., & Mastropieri, M.A. (in press a). Classroom applications of mnemonic instruction: Acquisition, maintenance, and generalization. Exceptional Children.

in press, Exceptional Children

Classroom Applications of Mnemonic Instruction:
Acquisition, Maintenance, and Generalization

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Running head: CLASSROOM APPLICATIONS

Abstract

The purpose of this investigation was to evaluate the effectiveness of mnemonic instruction of science content with mildly handicapped students. Of particular importance was the extent to which mnemonic instruction resulted in (a) higher levels of immediate recall, (b) long-term maintenance of learned content, and (c) any documented ability of students to transfer mnemonic strategies to their own learning. Mildly handicapped students were given either mnemonic instruction or more traditional instruction in a within-subjects design, in which treatment and unit order were counterbalanced across classrooms, for each of two weekly units in life science. Following a third week of mnemonic instruction, students were asked to generate and draw their own mnemonic pictures. Results suggested that mnemonic instruction resulted in substantial increases in initial content acquisition, and substantially higher delayed recall scores, over more traditional instructional procedures. Further, it was found that trained students were able to successfully generate and apply their own mnemonic strategies to novel content. However, in the generalization condition, it was also found that content coverage was substantially slower than conditions in which mnemonic pictures were externally provided. Finally, students overwhelmingly reported that they preferred using mnemonic instruction to traditional instructional methods, although some disagreement existed between preference for externally-provided or self-generated mnemonic pictures. Students also indicated they would prefer some form of mnemonic instruction to assist in their future learning. Implications for special education are provided.

Classroom Applications of Mnemonic Instruction: Acquisition, Maintenance, and Generalization

In recent years, mnemonic (memory-enhancing) strategy instruction has emerged as one of the most powerful instructional techniques in special education for promoting the acquisition of academic content (Mastropieri, Scruggs, & Levin, 1985; 1987; Mastropieri & Scruggs, in press a). Briefly stated, mnemonic instruction involves the integration of specific retrieval routes within to-be-learned content to facilitate recall. For example, to teach that vituperation is a word designating abusive speech, learners first are taught a "keyword" (Atkinson, 1975; Mastropieri, 1988) for the unfamiliar term, vituperation. In this case, viper is a good keyword for vituperation, because it is acoustically similar to vituperation, and can be pictured. The resulting mnemonic picture, then, would depict, not a person speaking abusively, but a viper speaking abusively to someone, therefore effectively integrating the pictured concept with the keyword. When asked to retrieve the definition of "vituperation," then, learners are asked to first think of the keyword, viper, think back to the picture with the viper in it, and think of what was happening in the picture to retrieve the information, "abusive speech."

Similarly, to facilitate recall of numbered or ordered information, the "pegword" method provides rhyming pegwords (one is bun, two is shoe, etc.) which interact with target information. Thus, to retrieve the information that the mineral corundum is number nine on Moh's hardness scale (Mastropieri, Scruggs, & Levin, 1985), the learner can be shown a picture of a car (keyword for corundum) stuck in vines (pegword for nine).

Numerous research studies have demonstrated the remarkable potential of mnemonic instruction for special education when applied in laboratory-type settings with experimental content, such as vocabulary lists and brief lists of facts, as compared with a variety of alternative experimental procedures (Mastropieri, Scruggs, & Levin, 1985; 1987). It also has been shown that mnemonic instruction can be used to learn abstract as well as concrete information, and that it has a facilitative effect on comprehension as well as recall (Mastropieri, Scruggs, & Fulk, in press). Nevertheless, it is only very recently that mnemonic strategies have been systematically employed in existing classroom settings, using actual curricular materials.

Pressley, Scruggs, and Mastropieri (in press) described the progression of cognitive strategy research from initial, tightly controlled investigations of the potential effectiveness of specific cognitive strategies, to the wide application of a variety of strategies in ecologically valid settings. Results of a number of such initial experiments were combined by Scruggs and Mastropieri (in press) to develop a broader model of "reconstructive elaborations," in which a domain of U.S. history content (World War I) was "reconstructed" along dimensions of meaningfulness and concreteness, and elaborated pictorially to promote comprehension and recall. For instance, information which was already concrete and familiar to learners (e.g., trench, tank) was presented as a mimetic reconstruction in which the target information was provided in a representative picture which was then elaborated with the response information. Information, on the other hand, which was familiar but abstract (e.g., U.S. policy) was presented as a symbolic reconstruction in which the target information was provided in a symbolic picture (e.g., Uncle Sam), elaborated with the response information. For information which was not familiar, and therefore not concrete (e.g., alliance, Rickenbacker), acoustic reconstructions employed keywords of the information (e.g., appliance, linebacker) elaborated with appropriate responses. Additionally, keyword-embedded first-letter strategies were employed to promote retrieval of lists of information (e.g., names of the countries in the Central Powers alliance).

Scruggs and Mastropieri (in press) taught mildly handicapped adolescents information about World War I using either the mnemonic techniques described above or a more traditional drill-and-practice condition, using pictures of the type likely to be found in textbooks. It was found that students in the mnemonic condition recalled substantially more content than more traditionally taught students, and maintained this advantage over a three-to-four day delayed recall interval. It was also found that each type of "reconstructive elaboration," including the first-letter strategy, was associated with significantly higher performance than traditional instruction.

Limitations of the Scruggs and Mastropieri (in press) investigation were that (a) only one chapter of one content area was covered, (b) students were taught individually, and (c) instruction was limited to one 30-minute lesson. In order to address these limitations, Scruggs and Mastropieri (1989a, b), and Mastropieri and Scruggs (1988, in press b) investigated the effectiveness of mnemonic instruction in social studies across specific topics, including both U.S. and state history, using regularly assigned special education or mainstream teachers, and instructional implementations ranging from two to eight weeks in length. The results of all these investigations were uniformly positive: students instructed mnemonically significantly (and substantially) outperformed students instructed by more traditional methods, on both immediate and delayed recall tests. In addition, teachers reported that mnemonic instructional materials were more appropriate for the special learning needs of their students, and students reported that they preferred mnemonic over traditional instruction. Finally, when weekly grades were administered, it was found that mnemonic instruction helped students raise their average grades from "D+" to "B".

Although results of these initial implementation studies were very positive, several issues were not addressed. First, although mnemonic instruction was apparently highly successful in promoting learning of social studies content, would the same be true of more conceptually-oriented science content? Although some initial abstract science concepts recently have been taught using mnemonic procedures (Mastropieri, Scruggs, & Fulk, in press; Mastropieri, Emerick, & Scruggs, 1988), longer-term implementation of a variety of science content domains using mnemonic instruction has not been attempted using mnemonic instruction.

That learning disabled (LD) or other mildly handicapped students could learn science content mnemonically was far from a foregone conclusion. In fact, at least two arguments recently have been advanced which suggest that mnemonic instruction may be an ineffective means of conveying science content. Shepherd and Gelzheiser (1987) argued that mnemonic elaborations would not allow students to learn fine distinctions among related science facts, such as "solar system, galaxy, constellation, and universe" (p. 258). Wong and Wong (1988), describing an anatomy lesson, argued, "the quality of comprehension and facilitation of retention of . . . structural properties of arteries may not be achieved with students using mnemonic techniques" (p. 145). In neither of these cases was relevant data provided to support the argument; nevertheless, each described concerns which can and should be addressed empirically. The present investigation was intended to provide some empirical evidence relevant to these issues.

Given that science content can be taught mnemonically, another issue of importance is the extent to which mildly handicapped students can learn to generalize mnemonic techniques to further their own learning. Although the importance of generalized strategy use can be overemphasized at the expense of content learning (Loper & Hallahan, 1982; Scruggs & Mastropieri, 1984), it can not be denied that an important role of special education is to make handicapped students more active participants in their own learning. Also, given that students can generalize effective learning strategies outside the original training situation, the implications for instructional development and design are much different that they may be if such strategies can not be generalized. Another important purpose of this investigation, then, was to gather some data on the extent to which mildly handicapped students could transfer complex mnemonic strategies, and to evaluate any costs or trade-offs which may arise in, for example, total amount of content learned, as a result of such training.

Some success previously has been achieved in promoting generalization of mnemonic strategies with mildly handicapped students. McLoone, Scruggs, Mastropieri, and Zucker (1986) trained learning disabled students to transfer use of the keyword method between English and Italian vocabulary. In this instance, however, generalization was achieved on experimental vocabulary lists in a highly structured training session. Mastropieri and Scruggs (1988), however, reported no evidence of spontaneous strategy transfer to novel content, after two, or even six weeks of daily mnemonic instruction. Clearly, if mnemonic strategy transfer is to occur, several important training components must be included. Based on previous research with mnemonic and other cognitive strategies, these components should include (a) previous successful experience using the strategy (McLoone et al., 1986), (b) explicit generalization training procedures (Mastropieri & Scruggs, 1987), and (c) attribution training (Borkowski, Weyhing, & Carr, 1988), in which success in learning is attributed directly to specific strategy use, rather than, for instance, more general indicators such as ability, effort, or luck.

The presently described investigation was designed to address, at least in part, all the above questions. In order to do this, a lengthy training program was implemented, in which four weeks of instruction were delivered over a five-week period, in pre-existing special education classrooms. During the first two weeks of instruction, two units of life science content were delivered in a within-subjects, crossover design in which treatment order (mnemonic and traditional) and unit order (vertebrate animals and invertebrate animals) were counterbalanced. This allowed for a direct comparison between mnemonic instruction and traditional instruction of science content.

The third week of instruction consisted of an implementation of mnemonic instruction of earth science content, to ensure that all students had the same recency of mnemonic instruction, and to evaluate the ability of mildly handicapped students to profit from mnemonic instruction of earth science content. During the fourth and final week of instruction, students were provided with another unit of earth science content, and provided with instruction in group generation and depiction of mnemonic strategies. In the case of the third and fourth week of instruction, performance was evaluated relative to reported strategy use. Finally, students were asked to rate the three types of instruction they had received (traditional, mnemonic, mnemonic transfer) with respect to several cognitive and affective variables.

Method

Subjects

Subjects were 20 learning disabled (N=19) and mildly mentally handicapped (N=1) students attending two self-contained special education classes in a middle school in a small midwestern community. The sample included 13 sixth graders, three seventh graders, and four eighth graders, who had a mean chronological age of 13 years, eight months (SD = 12 mo.). The seven girls and 13 boys had an average Wechsler Intelligence Scale for Children - Revised score of 80.1 (SD = 8.4), an average reading percentile score of 6.9 (SD = 6.4), and an average math percentile score of 5.4 (SD = 4.9), from the Basic Achievement Skills Individual Screener (1983). The final sample included one Black and nineteen Caucasian students who were attending self-contained special education classes daily, but were mainstreamed for two or three periods (out of seven) a day. All students had been enrolled in special education classes since approximately third grade. Students had been identified learning disabled or mildly mentally handicapped in accordance with state and federal guidelines.

Materials

Materials were developed specifically for this investigation, and were based on the textbook, Principles of Science (Heimler & Neal, 1986). This text was widely adopted for junior high school use in the state in which the investigation was conducted. Materials included important content from four chapters (9, 10, 16, 17): (a) vertebrate animals, (b) invertebrate animals, (c) earth history, and (d) geology. For both sets of materials (mnemonic and traditional), teacher presentation scripts, overhead transparencies, and student booklets were included. Each set of materials is described separately below.

Mnemonic condition materials. For the mnemonic condition, pictures were developed to represent all important content information, according to the model of reconstructive elaborations (Mastropieri & Scruggs, 1989; Scruggs & Mastropieri, in press). When information was considered to be concrete and familiar to target mildly handicapped learners, mimetic reconstructions were developed in which target stimulus and response information was depicted interacting pictorially. For instance, to teach that earthworms are roundworms that live in the earth, have segmented bodies and many hearts, a representational picture was constructed of a round earthworm with a segmented body and many hearts, living in the earth, as shown in Figure 1. This mimetic reconstruction was employed because it was thought that learners were familiar with all relevant concepts, and the interaction of these concepts was what was being taught. Depicting the interaction of all this information pictorially was intended to make the information more concrete to learners.

Insert Figure 1 about here.

When information was considered to be abstract to learners, symbolic reconstructions were employed, in which symbolized representations are shown pictorially interacting with relevant target information. For example, to teach that birds are warm-blooded, a warm, sunny scene is depicted to symbolize warm-blooded. Since birds were thought to be both concrete and familiar to target learners, a mimetic picture of a bird was shown in a warm, sunny scene, as in Figure 2. Again, the direct interaction of the bird with the sunny scene was intended to facilitate acquisition of the target information, that birds are warm-blooded.

Insert Figure 2 about here.

When information was considered to be unfamiliar to learners, acoustic reconstructions were employed, in which target information was linked with acoustically similar keywords. For instance, to teach that the concept of radial symmetry refers to structurally similar body parts that extend out from the center of an organism, such as a starfish, an acoustically similar keyword, "radio cemetery," was constructed from the unfamiliar term, radial symmetry. In the picture, the radio cemetery was shown in the shape of a star, with radios as headstones, and skeletons dancing to the music from the radios. Each arm of the star is shown to be similar in appearance to each other arm, to enforce the concept, as shown in Figure 3. For another example, to teach that trichina is a roundworm found in uncooked pork that causes illness in humans, the keyword "trick" was employed to depict trichina. Since "trick" is not entirely concrete, a verbal elaboration was presented of trichina springing from a pig and saying, "I have a trick...I'll make you sick!" as in Figure 4.

Insert Figures 3 and 4 about here.

Mnemonic pictures of the type described above were developed for three of the four chapters. These pictures, as shown in Figures 1-4, were copied on transparencies for use with overhead projectors. In addition, teacher scripts were included which provided information on the target content, as well as mnemonic retrieval information. For example, for the trichina picture, the accompanying teacher script read as follows:

> When people eat pork (from pigs) that is not cooked all the way, they can get a disease called trichinosis. Severe muscle pains, fever, and weakness are the symptoms of this disease. Trichinosis is caused by a parasitic roundworm named trichina.
>
> To help you remember that trichina is a roundworm parasite (or parasitic roundworm) that comes from pigs and makes people sick, think of the keyword for trichina: trick. What is the keyword for trichina? (Elicit responses). Think of this picture of a person about to eat pork that isn't cooked all the way, when he sees a roundworm pop out of a pig. The trichina is a roundworm and a parasite that is living inside the pig. The trichina says, "I have a trick...I'll make you sick!" This will help you remember that trichina are parasitic roundworms that come from pigs and make people

sick. What is a trichina? What do you think of when I ask you for the name of a parasitic roundworm that comes from pigs and makes people sick? (Elicit responses and provide feedback). Tell me everything you can about trichina. What is a parasitic roundworm that comes from pigs and makes people sick? (Elicit responses and provide feedback).

In addition to mnemonic transparencies, and teacher scripts, student workbooks and worksheets were included. The workbooks included the mnemonic picture and accompanying target information, without strategy information, while the worksheets included practice activities, such as relabeling and describing unlabeled mnemonic pictures.

Mnemonic materials for the generalization unit contained target information, as described above, but did not include mnemonic pictures or descriptions of mnemonic strategies. Instead, blank spaces were left in student workbooks. Students were encouraged to draw their own mnemonic pictures in these spaces, in the place of workbook activities. Additionally, overhead transparencies were used by the teacher that contained the typewritten target information.

Traditional instruction condition. Materials in the traditional instruction condition paralleled those in the mnemonic condition, with the exception that no mnemonic strategy information was provided. For example, the overhead transparencies consisted of target information only, without reference to mnemonic elaboration. In addition, students were given workbooks which were identical to mnemonic condition workbooks with the exception that all mnemonic strategy information was deleted. Student worksheets were taken from the published materials to accompany the text and included traditional practice activities on target information, such as matching and fill-in-the-blank activities. Traditional instructional materials were developed for the two life science units only.

Design and Analysis

Training phase. In order to avoid problems associated with random subject assignment in school settings, classroom effects, and differential attrition, a crossover design was employed in which each of two self-contained classrooms received both mnemonic and traditional instruction for life science. In order to control for any possible effects due to relative instructional unit difficulty or treatment order, these two variables were counterbalanced. That is, while one classroom received the vertebrate unit mnemonically and the invertebrate unit traditionally, the second classroom received the vertebrate unit traditionally and the invertebrate unit mnemonically. If one type of instruction were more effective, then, statistical analysis would reveal an instructional unit by classroom interaction. No main effects for classroom or unit due to type of instruction would be expected, since type of instruction varied across chapters and classrooms. Also, since, in this design, each student acted as his or her own control, differential subject attrition was not a potential problem. In this investigation, data were available for no fewer than 18 subjects for any given measure.

Generalization phase. The third training week was delivered mnemonically to both classes, to prepare them for the generalization week to follow. Effectiveness of strategy training was evaluated by comparing, for each subject, score on items for which strategy information was recalled, with score on items for which relevant strategy information was not recalled. Effectiveness of generalization training, the fourth week, was evaluated in the same manner. In addition, informal comparison was made on the relative amount of content covered and mastered between mnemonic training and generalization units.

Procedure

Training phase. Project staff, consisting of certified special education teachers, administered training in the two classrooms, with the regularly-assigned special education teacher in attendance. Due to a school's spring break, the first and second units were separated by a period of one week. Each instructional unit (including the third and fourth units) was taught for one week, consisting of four fifty-minute lessons, followed by a unit test on the fifth day. A review was provided on the fourth day but not on the fifth day prior to the test. In all cases, for both conditions, teaching employed the principles of effective instruction, as described by Mastropieri and Scruggs (1987). These principles include insuring maximum levels of engaged time-on-task throughout each lesson, and ensuring each lesson included (a) daily review (excluding the first day of each unit), (b) statement of objective, (c) delivery of information, including learner questioning and feedback, (d) guided practice, (e) independent practice, and (f) formative evaluation of learner progress. The major difference in instruction between the two conditions was that, in the traditional condition, no explicit strategy or retrieval information was provided to learners, who were, instead, told generally to work hard and try their best. For both types of instruction, a behavior management system was employed in which students who earned all or all but one of their behavior points each day were provided with a small prize. All training sessions were observed and videotaped by project staff.

At the end of each of the two unit of instruction, students were administered individually a 23- or 27-item production test, in which they were asked to state verbally answers to all target questions, such as "What is radial symmetry?" Also, for each item, students were asked to state how they had remembered the information. After the end of testing for the generalization unit (see below), students were also administered a surprise delayed recall test of a sample of eight items from the first two weeks of instruction, as well as strategy questioning for these items.

Generalization phase. The third week of instruction, on earth history, was administered by the regular special education teachers, and served to prepare students for the generalization unit to follow. On the fifth day, students were again administered a unit test, followed by strategy questioning.

The generalization unit, on geology, was again administered by project staff. However, instead of providing strategy information, as in the previous two weeks, teachers provided content information, and asked students to generate keywords (if necessary) and interactive mnemonic pictures. First, teachers presented the important information verbally to the class, as well as used the corresponding overhead transparency. Then, instead of proceeding to provide the students with the mnemonic strategy and picture, teachers said, for example,

> Now, what would be a good way to remember this information? Remember how we used the keywords and pictures to help us remember before? Can anyone think of a keyword for this important information [e.g., the earth's core is made of iron and nickel]? Remember the keyword can be the same word or sounds like the word we need to remember. Also remember that the keyword has to be easily pictured."

Teachers then moved to the blackboard and began to elicit keywords from students and wrote all student responses on the blackboard. For the example of earth's core, some students thought of "door", "ore", "cord", and "apple core". Following the generation of the list of keywords, teachers prompted the students to select of one of the most appropriate keywords (in their judgment). The criteria used by teachers consisted of similarity of acoustic properties, concreteness, and the degree to which it could be easily drawn. Teachers restated the criteria when selecting the class keyword. Next, teachers prompted students to think of the keyword doing something together with the to-be-learned information. In the earth's core example, teachers stated, for example. "Now what would be a good picture of a "door" doing something together with iron and nickel?" (one class used apple core, while the other class used door for the keyword for core). Again, responses were elicited from all students. Following this, teachers drew the interactive illustration on the overhead transparency and had students draw their pictures on the student workbooks. While students were drawing, teachers circulated around the room and provided feedback. This activity replaced workbook practice activities that were used in the previous mnemonic conditions. In both classrooms, teachers ensured that all students contributed to the generation of mnemonic strategies and interactive illustrations.

Finally, throughout the instruction teachers provided explicit attributional training with the strategy instruction. For example, teachers consistently referred to success or failure as being directly attributable to the strategy and students' ability to use the strategy, rather than any other internal or external sources. One statement used was the following, "You have learned this information so well because you used this good strategy." In summary, teachers promoted effective generalization throughout the instruction by (a) referring students back to previous mnemonic instruction, (b) providing explicit prompting and feedback for keyword and interactive image generation (see Mastropieri & Scruggs, 1989), (c) providing feedback on mnemonic drawings, and (d) providing explicit attribution training.

On the fifth day of generalization instruction, students were given a test on the content which had been covered to that point. After each test item, students were again asked to describe how they had recalled the information.

Survey information. During the week subsequent to the generalization unit, project staff reviewed with students the three types of instruction each had been exposed to: traditional, mnemonic, and mnemonic transfer. Students were asked to rate these types of instruction with respect to (a) how much they enjoyed the instruction, (b) how much they had learned, (c) how hard they had tried, and (d) how much they would like to use the method again.

Scoring. Students were awarded one point for each test item answered correctly, and one point for each mnemonic strategy correctly described. One hundred percent agreement was reached on these scores by two raters unaware of training condition.

Results

Training phase. Test score data were entered into a two (classroom) by two (instructional unit) analysis of variance with repeated measures on the chapter factor. Since the two unit tests differed somewhat in number of items, scores were converted to proportions and therefore statistics are reported on arcsin-transformed proportion scores (Ferguson, 1982).

As stated above, significant main effects due to instruction were not possible, as type of instruction varied systematically across both classrooms and chapters. In fact, neither classroom effect, F(1,16) = 2.77, p = .116, nor instructional unit effect, F(1,16) = .12, p = .734, was statistically significant. However, a very strong effect was found for classroom by instructional unit interaction, F(1,16) = 87.57, p = .000. Descriptive analysis of this interaction revealed that, in each classroom, performance was substantially higher under mnemonic instruction, as shown in Figure 5. In classroom one, the mnemonic instructional advantage was 77.8% to 44.3% correct; while in classroom two the mnemonic advantage was 67.9% to 33.3% correct.

Insert Figure 5 about here.

On the delayed recall test (two to four weeks, counterbalanced across classrooms), it was found that students retained 59.3% of mnemonically instructed information sampled, compared with 38.0% of traditionally instructed information. These corresponding sets of raw scores were found to be statistically different according to a *t*-test for correlated samples, *t*(19) = 2.52, p = .022. It was also found that mnemonic strategy use was predictive of performance in mnemonic conditions, in that reported strategy use was significantly correlated with performance, Pearson r = .529, p = .020.

Generalization phase. During the third week of training, it was found that implementation of mnemonic instruction by the regularly assigned teachers resulted in similarly high performance scores, with an average of 76.3% (SD = 21.3%) items answered correctly. During this unit, reported strategy use was also found to be significantly correlated with performance, Pearson r = .786, p = .000.

Support for the relationship between reported mnemonic strategy use and performance during the third week of instruction was further provided by an examination of scores for each subject, for items for which mnemonic strategy use was reported, and items for which mnemonic strategy use was not reported. It was found that when students reported using relevant mnemonic strategies, they answered an average of 93.7% (SD = 16.3%) items correct. When they failed to retrieve the relevant strategy, however, they answered an average of 47.3% (SD = 30.2%) correct. Due to the presence of "ceiling" and "floor" effects and consequent constrained variability, these data were analyzed by means of the non-parametric Wilcoxon matched-pairs signed-ranks test (Siegel, 1956), which yielded a Z = 2.98, p = .003.

During the generalization training unit, students effectively generated their own mnemonic strategies. Mean proportion of content covered answered correctly was 52.5% (SD = 21.0%), and highly correlated with strategy use, Pearson r = .712, p = .000. When students reported using mnemonic strategies, they answered 99.6% (SD = 1.6%) of relevant test items correctly. When they did not report use of mnemonic strategies, they recalled only 12.2% (SD = 20.0%). These two sets of scores were significantly different according to a Wilcoxon matched-pairs, signed-ranks test, Z = 2.98, p = .003.

However, it was also found that substantially less content was covered in the same time period in the generalization unit than when mnemonic strategies were directly taught. Although items across instructional units cannot be matched exactly for difficulty, it was found that only 33% to 39% as much content was covered during the generalization unit as had been covered during the first or second week of instruction, in which mnemonic strategies were explicitly provided.

Student survey information. Students were asked to rate the three forms of science instruction, traditional, mnemonic, and mnemonic transfer, according to how much they enjoyed the instruction, how much they had learned, how hard they had tried, and how much they would enjoy using it again. Surveys were completed by nineteen students, and are reported in Table 1. An examination of this table reveals that mnemonic instruction, either generated or provided, was overwhelmingly preferred over traditional instruction. It was also seen that mnemonic instruction was generally preferred over mnemonic transfer, which was also seen to be associated with the most effort on the parts of students.

Insert Table 1 about here.

Discussion

In this investigation, it was found that mnemonic instruction can produce strong and lasting effects on the acquisition and maintenance of science content. As seen in previous research, the effect of mnemonic instruction was not only statistically significant, but exceeded by a wide margin (nearly two-to-one) learning by more traditional, strategy-free instruction. Comparison of student strategy reports with performance information provided further evidence for the powerful facilitative effect of mnemonic strategy use.

Mildly handicapped learners have frequently been characterized, by both researchers and teachers, as deficient in semantic memory (e.g., Swanson, 1987). It is likely that these memory deficits stem largely from (a) a relative paucity of prior knowledge on which to "hook" new information, and (b) a lack of effective strategies for systematically encoding new content information. Baker, Ceci, and Hermann (1987) have described these difficulties as problems with both the "structure" and "process" of memory. Perhaps one reason mnemonic strategies have been so successful with these learners is because they provide systematic procedures for the retrieval of target information. Learners are taught, then, not only important content, but also the appropriate encoding strategies for later retrieval of this content. By contrast, most traditional instruction merely provides new information to the learner, perhaps highlighting the most important content and providing activities intended to heighten interest, but does not provide explicit retrieval information. The result is often similar to replacing books in a library without reference to a systematic filing system. Even though the books are in the library, they are of no use because they cannot be retrieved. Scruggs, Mastropieri, and Levin (1985) described an investigation in which non-mnemonically instructed mildly mentally handicapped students acquired relevant responses to new vocabulary words, but failed to acquire the association between the response and the new vocabulary label. On the other hand, mnemonically instructed students not only acquired target responses, but also were able to associate them with the appropriate stimulus term.

Contrary to previous speculation, mnemonic instruction has proven highly effective for teaching science content. However, this not mean that mnemonic instruction can or should be used to meet all instructional objectives in science. As we have argued previously (Scruggs, Mastropieri, & Levin, 1987), mnemonic instruction, as powerful as it has been shown to be, is not an educational panacea. In all special education, specific instructional procedures must be directly linked with specific instructional objectives. However, when the instructional objectives involve the acquisition and retention of new semantically-based information, mnemonic instruction may very well be the optimal procedure.

It was also found in the present investigation that students, as a group, could successfully generate their own mnemonic strategies and apply them to novel content. Evaluation of strategy reports suggested that these strategies were, again, strongly predictive of academic performance. However, it was also found that the pace at which students were able to move through content was sharply diminished. Such a finding suggests that the facilitation of mnemonic transfer may be purchased at the expense of the additional content that may have been acquired had mnemonic pictures explicitly been provided. Although learner independence is a major objective of special education programs, it is also true that special educators are obligated to ensure that their student acquire a thorough knowledge base. These objectives may not be mutually exclusive; however, when planning instruction it is important to prioritize instructional objectives.

It should also be acknowledged that the present investigation offered only an initial evaluation of mnemonic transfer, and that future research may well uncover variables for facilitating the pace of content coverage under mnemonic transfer conditions. Such variables could include (but not be restricted to) additional practice with mnemonic transfer, more explicit rules regarding keyword generation, or more effective ways of facilitating group brainstorming. Further research could provide important information on these or other variables.

One frequently overlooked factor in instructional research is the expressed opinion of the students on whom the treatment is being evaluated. It has been shown in previous investigations (e.g., Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1987) that learning disabled students are aware of the facilitative effect of mnemonic instruction. It has also been seen that special education teachers rate mnemonic instructional materials as significantly more appropriate for the needs of their students (e.g., Scruggs & Mastropieri, 1989a). However, the present investigation provided further information on student acceptability of mnemonic instruction, including mnemonic generalization training. In this case, it was seen that mnemonic instruction was greatly preferred over traditional instruction, and seen to be more effective. It also appeared that most students appreciated that independent generation of mnemonic strategies involved more cognitive effort than either mnemonic or traditional instruction. Some disagreement did emerge, however, with respect to enjoyment of the mnemonic transfer unit, which some students seemed to prefer most, and some to prefer least. Nevertheless, student survey data provided overwhelming support for some form of mnemonic instruction over more traditional methods.

One potential difficulty of mnemonic instruction is that effective strategies may be time consuming to develop, as least as compared with less effective but more generic strategies such as rehearsal. In addition, mnemonic pictures may be difficult to produce, particularly for teachers who are not artistically inclined (but see Mastropieri, Emerick, & Scruggs, 1988). Nevertheless, once materials have been developed, they can be used again and again; and some very explicit information on developing mnemonic materials has been provided by Mastropieri (1988) and Mastropieri and Scruggs (1989). It is also true that generalization training, if successful, does not require the use of pictures, although some initial exposure to mnemonic pictures seems to be necessary. The most important advantage of mnemonic instruction, however, is the fact that it is an exceptionally powerful facilitator of learning for the students who have the most to gain from such instruction.

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Table 1: Student Survey Results

Most Favored (in percent)

	Mnemonic	Transfer	Traditional
1. Enjoyed most	68.4	26.3	5.2
2. Learned most	73.7	21.1	5.2
3. Tried hardest	21.1	57.9	15.8
4. Use again	63.2	26.3	10.5

Least Favored (in percent)

	Mnemonic	Transfer	Traditional
1. Enjoyed least	0	31.6	68.4
2. Learned least	0	26.3	73.7
3. Tried least	42.1	10.5	47.4
4. Use again	0	36.8	63.2

Figure captions

Figure 1: Mimetic reconstruction of earthworm information.

Figure 2: Symbolic reconstruction of bird = warm blooded.

Figure 3: Acoustic (keyword) reconstruction of radial symmetry = similar body parts extending out from the center, as a starfish.

Figure 4: Acoustic reconstruction of trichina = roundworm, found in pork, causes illness.

Figure 5: Classroom by chapter interaction.

EARTHWORM

- lives in the earth
- segmented body
- many hearts
- roundworm

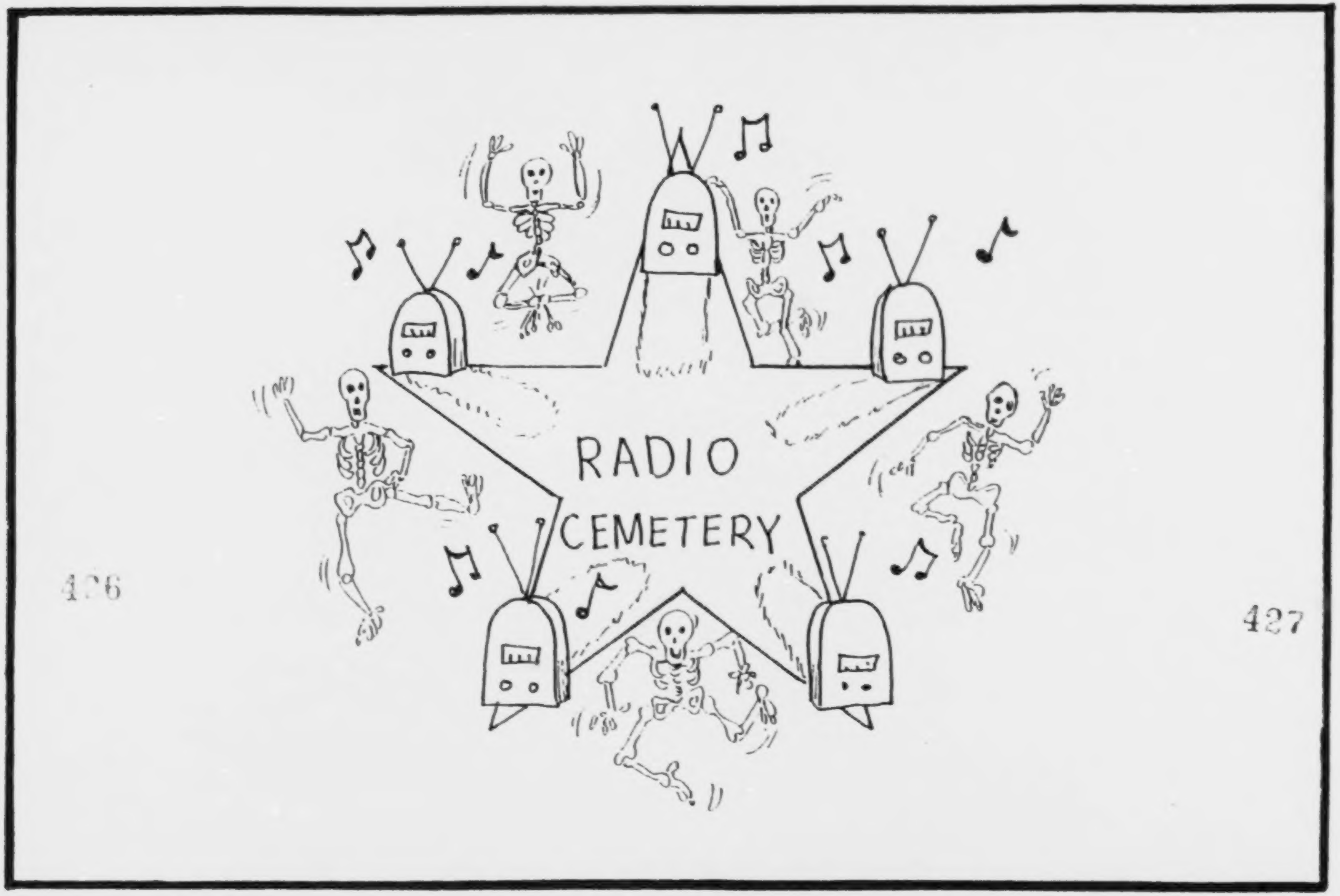
BIRDS

- warm blooded
- feathers

RADIAL SYMMETRY

(Radio Cemetery)

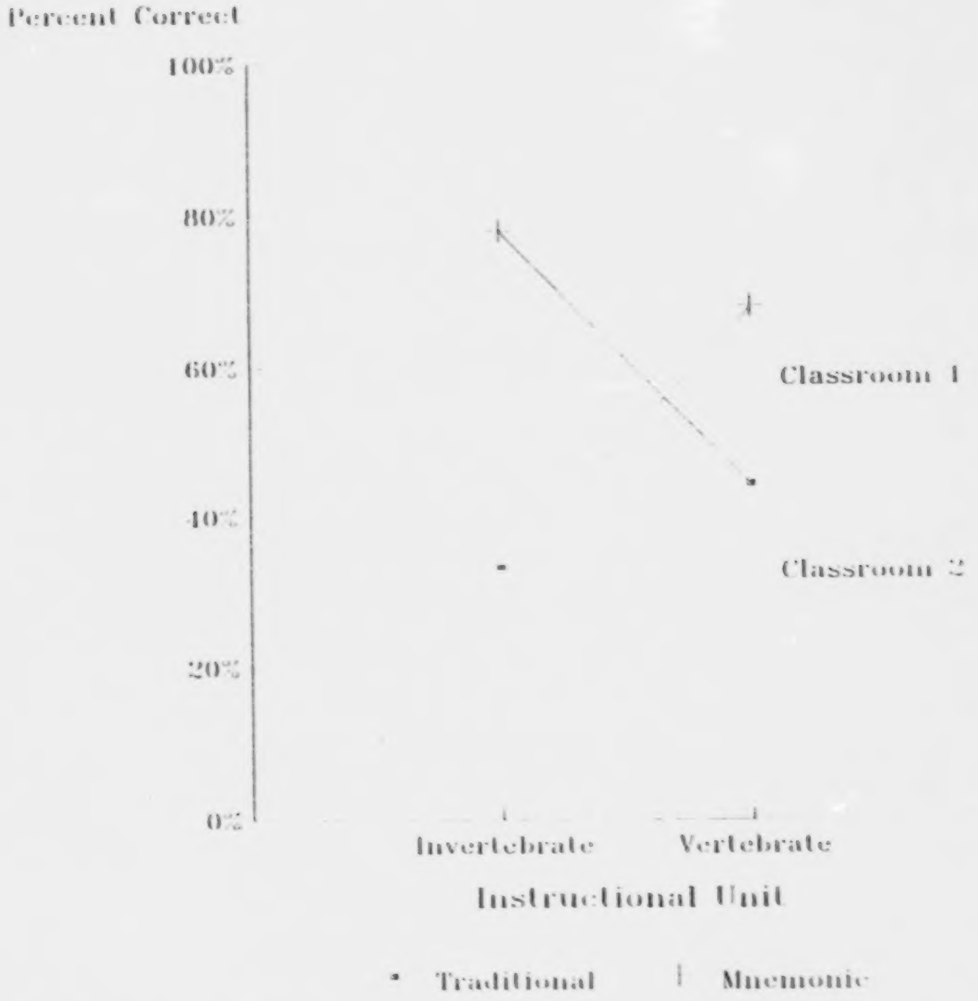
-body parts extend out from center



TRICHINA
(Trick)

-Parasite
-Roundworm
-Makes people sick
-Comes from pigs

I HAVE A TRICK ...
I'LL MAKE YOU SICK!



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Appendix T

Scruggs, T.E., & Mastropieri, M.A. (in press b). Effective mainstreaming strategies for mildly handicapped students. Elementary School Journal.

in press, Elementary School Journal

Effective Mainstreaming Strategies for Mildly Handicapped Students

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Running head: EFFECTIVE MAINSTREAMING

Abstract

This paper outlines effective instructional strategies which can be used to promote school success of mildly handicapped students in the mainstream. These strategies are supported by empirical research and are described with respect to presenting characteristics of mildly handicapped students, including deficits in attention, memory, language/intelligence, social/emotional behavior, basic skills, and organizational/study skills. These characteristics, it is argued, provide more direct implications for instruction than, for example, consideration of categorical designation or use of general "mainstreaming" strategies which may not completely account for individual differences. This model of effective mainstreaming strategies is described within the overall model of effective teaching.

Effective Mainstreaming Strategies

In this article, we present a model for the effective instruction of mildly handicapped students -- including students with learning disabilities, behavior/emotional disorders, and mild mental retardation -- in regular classrooms. We argue that such a model must account for the presenting characteristics of the mainstreamed students involved, rather than the categorical designation applied to such students. In addition, although certain approaches are currently being promoted as "mainstreaming" strategies, we caution against considering any specific strategy a panacea for mainstreaming. We contend that teachers must first attend to presenting characteristics of the student, with particular reference to the curriculum being covered, in order to develop and implement optimal mainstream instructional models.

Based upon our experience as teachers, researchers, and consumers of research, we suggest that students must function acceptably within eight general areas in order to succeed in mainstream environments. These areas are not completely independent; nevertheless, each brings strong implications for instructional practice:

1. Attention, including hyperactivity and distractibility. Attention has long been identified as a major prerequisite for school learning (Hewett, 1968). Attentional deficits have frequently been observed in mildly handicapped students

(Hallahan, 1975; Hallahan, Kauffman, & Lloyd, 1985; Hallahan & Reeve, 1980; Kauffman, 1981; Keogh & Margolis, 1976; Pelham, 1981; Zeaman & House, 1979).

2. Memory, including memory search, short term and long term memory, and spontaneous (i.e., untrained) use of efficient memory strategies. Memory deficits, particularly as manifested in relative inability to recall school content or school rules and procedures, have been shown to be common characteristics of exceptional students (Baker, Ceci, & Herrmann, 1987; Bauer, 1987; Ceci, 1985; Detterman, 1979; Link, 1980; MacMillan, 1982; Mastropieri, 1983; Mastropieri & Scruggs, 1988; 1989; Swanson, 1987; Torgesen, Rashotte, Greenstein, Houck, & Portas, 1987).

3. Intellectual abilities. General deficits in intellectual functioning are frequently used as identifying characteristics of mentally retarded students (e.g., MacMillan, 1982). However, deficits in intellectual functioning have been identified in learning disabled and seriously emotionally disturbed students (Bullock & Reilly, 1979; Kavale & Forness, 1985; Kavale & Nye, 1985/86; Mastropieri, Jenkins, & Scruggs, 1985).

4. Language. Language deficits including receptive and expressive langauge problems are frequent characteristics of learning disabled, mentally retarded, and seriously emotionally disturbed students (e.g., Kavale & Nye, 1985-1986).

5. Social/behavioral characteristics, including disruptive behavior, social withdrawal, social aggression, interpersonal

skills with peers, teachers, and school administrators, cultural or language differences, and general social skills. Such social behaviors are also strongly related to school achievement. Although common causes for referral for students characterized as seriously emotionally disturbed, deficits in social/behavioral areas commonly have been observed in other handicapped populations (Bryan, 1974; 1976; Bryan & Lee, in press; Greenspan, 1979).

6. Affective or motivational factors, strongly related to achievement in school (Nicholls et al., 1989), have also been identified as potential deficit areas for mildly handicapped students often as a consequence of a history of school failure (Licht & Kistner, 1986; Siegel, 1979).

7. Basic academic skills, including basic reading, writing, spelling skills, and arithmetic skills are common reasons for referral of all mildly handicapped students (Hallahan & Kauffman, 1988; Hallahan, Kauffman, & Lloyd, 1985; Mastropieri & Scruggs, 1987).

8. Study/organizational skills, including listening, notetaking, study strategies, research and composition skills, and test-taking skills. Lack of such skills often results in mainstreaming failure, particularly at the secondary level (Alley, Deshler, & Warner, 1979; Mastropieri, Jenkins, & Scruggs, 1985; Scruggs & Mastropieri, 1986; 1988).

Each of the above areas interacts critically with curriculum, instructional objectives, and instructional strategies. Deficits in any of these areas can seriously inhibit the student's ability to function successfully in a mainstream class environment. Conversely, if students exhibit competence in all component areas, mainstream success is very likely to occur. Consideration of the eight component areas listed above will lead directly to instructional implications. Additionally, regular education teachers may wish to consider these strategies for use with students prior to actual referral for special education services. In some cases, employment of one or more of the recommended strategies may eliminate the need for special education services. These instructional strategies are now described, within each area:

Eight Components of Mainstream Success

Attention

The first consideration in identifying a deficit is determining that an overriding deficit does not lie in some other area. In the case of attention, there are at least two other problems which may only appear to manifest themselves as attentional problems: basic skills deficits, and motivational/affective deficits. Often, students may not attend to school tasks because they lack basic skills necessary for attending to these tasks. Students with reading disabilities, for example, are commonly considered inattentive, because the printed page holds so little meaning to them. When unable to read required material, their eyes may wander around the room, looking for additional cues to the content, or simply attempting to avoid unpleasant tasks. Such students are communicating that basic skills deficits, rather than attentional deficits, are causing their mainstreaming problems. Relevant strategies for these students are provided in the basic skills section.

Additionally, students lacking _motivation_ or task-appropriate _affect_ may at first glance appear to be exhibiting deficits which are primarily attentional in nature. For a variety of reasons, students may simply not _want_ to participate (or think they do not). Students exhibiting these problems should be provided with strategies for improving motivation or affect, as described later in this article. For students whose primary difficulty lies in the area of sustained attention to mainstream classroom tasks, however, effective strategies for improving attending skills are available.

1. Modify the rate and presentation of the curriculum. If information is presented at too fast a rate, or at too abstract a level of conceptualization, student attention may decrease, simply because some students have become "lost" in the content. Direct questioning of students can help reveal whether this is the source of the attending problem. If so, it may be possible to slow the rate of presentation, include more visual organizers or media, such as an overhead projector, or include more concrete examples in the presentation. These and related adjustments can be made without appreciably altering the overall pace at which curriculum is covered.

2. Direct appeals. Sometimes, a student may develop inefficient attending habits, not directly realizing that such behavior is of real concern to the teacher. This may occur with students who have become used to small special education classes and now feel insignificant in a large regular education class. In these cases, teachers may find that simply speaking to the student alone, pointing out that the student's learning is important to the teacher, and emphasizing the importance of paying attention in class, are remarkably effective in improving attention. To be effective for an extended period of time, however, such appeals may have to be made at regular intervals.

3. Proximity. In some cases, increasing the proximity of the inattentive student to the teacher and increasing the rate of questioning could produce a favorable response. Some students may be much more likely to attend if they feel that the teacher is attending to them. Encouraging questions and comments from the student with positive feedback can also be an important strategy in promoting attention.

4. Reinforce attending. Set an egg timer, alarm clock, or tape recorder to sound at random intervals. If students are attending when the sound occurs, they can be given reinforcement, such as verbal praise, points, or tokens which can be saved and exchanged at a later time for desired objects or privileges (if,

for example, the student earns 80% of possible tokens by a specific date). If such an approach seems likely to promote jealousy or resentment among mainstream students (e.g., that the student is able to work for rewards that are unavailable to others), consider making the reward a class privilege, such as additional recess time, or a favored activity. This may help the class feel they are all invested in the target student's improved attending.

5. Teaching self-recording strategies. In many cases, students do not attend because they have not learned specific strategies for attending. Lloyd and Landrum (in press) have described validated techniques for training students to attend to task. In a typical self-recording training program, the teacher first discusses the problem with the student, prompts the student to acknowledge that attending is a problem, and that it would be in that student's own interest to improve attending skills. In many cases, this step is relatively simple, while in others, teachers may need to provide specific instances in which inattention caused problems. Students are then asked to record whether they were attending during specific units of instruction. Generally, this recording is cued by tape recorded "beeps" which occur at random intervals (e.g. Hallahan, Lloyd, Kosiewicz, Kauffman, & Graves, 1979), but kitchen timers (Workman, Helton, & Watson, 1982), and recorded music segments (Shapiro, McGonigle, & Ollendick, 1980) have also been used. Typically, the cuing

interval has been from about one to about five minutes, depending on the needs of target students. In some cases, cues are not used -- students are asked to record their attending "when they think of it" -- but when directly compared (Heins, Lloyd, & Hallahan, 1986), cued conditions appear to produce more stable levels of attending.

When students hear the cue, they are instructed to record, with, for instance a "+" or "-", whether or not they were attending. Students can be reinforced (with praise, privileges, tokens, or other rewards) for recording at all appropriate times, or for approximating the results of the teacher's random recording of their attending. Research has suggested that, when students record their own attending, academic engagement and achievement improve.

Once self-recording becomes accurate and automatic, and attending increases to desired levels, cuing can be faded out. However, students should continue to be advised of the importance of attending to task, and should be provided with feedback on both their level of attending and assessment of their attending.

Self-recording strategies can be used for attending to teacher presentations, attending to group activities, or attending to individual work activities. A. Graves (1986) and DuncanMalone and Mastropieri (in press) have described self-recording procedures for comprehending written text, in which students have been trained to record whether each successive paragraph was understood. If not, because of comprehension or problems in attending, students were instructed to re-read the paragraph.

Frequently, self-recording strategies are taught by special education teachers in special education classrooms. This self-recording strategy does not always generalize to regular classroom environments, but it is more likely to happen if it is also directly prompted and monitored in by regular classroom teachers. With effective communication between regular and special educators, attentional problems can be effectively remediated.

Memory

Memory deficits are among the most commonly described characteristics of mildly handicapped individuals; nevertheless, other problems may masquerade as memory problems. Most prominent among these are attentional problems. That is, if students do not attend to specific tasks, those tasks will not become part of the students' experiences, and consequently, will not be remembered. It is therefore important to determine that information not remembered was previously attended to -- that the problem is memory and not attention. If attention seems to be the primary problem, the strategies mentioned above should be considered.

It is also possible that what appear to be memory deficits are actually problems more directly related to basic skills and organizational/study skills. Often, the reason students remember important school information is because they took it home and studied it, from textbooks or notes, after school. Such procedures require good listening-notetaking skills, and adequate reading skills to go over written material. The role of basic skills and organizational/study skills deficits in later retrieval can not be underestimated; nevertheless, it is true that memory problems based on these deficits can still to a certain extent be addressed by specific instructional procedures. However, if basic skills or organizational/study skills is a primary problem, this also should be carefully attended to, as described in those sections of this article. Following are strategies for dealing with memory deficits.

1. Intensify instruction for later recall. This can be achieved by highlighting important points, on the blackboard or overhead projector, and having students repeat the information many times. Direct questioning of specific information to be remembered has been shown to be directly related to improved recall (Brophy & Good, 1986). Rehearsal, by itself, is not always an effective memory strategy (Mastropieri, Scruggs, & Levin, 1985), but frequent highlighted presentation of target information can allow students more opportunity to process this information and incorporate it within their own knowledge base.

2. Use external memory systems when appropriate. Some information need not be remembered if it can be retrieved in other ways. For example, memory for the day of the month is not

necessary for those who have easy access to a calendar. In some math classes, direct recall of math facts may be less necessary for students who know how to use calculators. Memory for one's own social security number, home address or important telephone numbers are not necessary to memorize if this information is written down and contained in wallets or purses. Other school-relevant information, such as class schedules, can be written down in places where it is easy to retrieve. These "external memory" systems can relieve the burden of memorizing things that are not necessary to memorize. Before relying on external memory systems, however, it is important to be certain that this information can be efficiently stored in this way. Locker combinations, for example, are more secure if they are not written down at all. Also, external memory systems used during a test are also referred to as "crib sheets," or "cheating." Before encouraging use of external memory, teachers should be certain when such memory aids are, and are not, appropriate.

3. _Use mnemonic instruction_. Mnemonic techniques were first developed by the ancient Greeks to improve recall when there was little availability of written materials (Yates, 1966). These techniques have also shown to be effective for improving the memory of mildly handicapped learners in a variety of settings, across a variety of content domains including mainstream settings (Mastropieri & Fulk, in press; Mastropieri & Scruggs, 1989; Scruggs & Mastropieri, in press a). Essentially, mnemonic

techniques involve forming strong associations between new information and learners' prior knowledge system. For example, to remember that most typical _frogs_ belong to the family _Ranidae_, students are first given a "keyword" for Ranidae. A keyword is a word that sounds like part of Ranidae, but is already in students' knowledge base, and is easily pictured. In this example, _rain_ is a good keyword, because it sounds like the first part of Ranidae and is easily pictured. In the next, elaboration step, an interactive picture is shown of a _frog_ sitting in the _rain_. When later asked about the Ranidae, students retrieve the acoustically similar keyword "rain," think of the picture of the rain, remember what else is in the picture, and retrieve the correct response, _frog_. Mnemonic techniques for special education students have been experimentally validated in over 30 experiments, and collectively represent some of the most powerful interventions in the special education literature (Mastropieri & Scruggs, 1989: Scruggs & Mastropieri, 1990).

Specific mnemonic techniques can be used to improve recall in any content or skill area, including science, history, geography, language, reading, mathematics, and spelling. Description of all available mnemonic techniques is beyond the scope of this article, but the reader is referred to Mastropieri and Scruggs (in press), for complete descriptions of these techniques and how they can be employed in classrooms.

4. Promote effective encoding. When specific mnemonic strategies have not been developed or are unavailable, teachers should do all they can to enhance the meaningfulness, familiarity, and concreteness of content they are teaching. This can be achieved by requiring students to actively process the information, rather than simply listening to or reading the presentation. After important content to be remembered has been identified, teachers should question students on all essential aspects of this content, and attempt to tie it into their prior knowledge as much as possible. With new terminology, vocabulary, or names of unfamiliar places or people, teachers should ask students to attend to the acoustic properties of the new words; that is, what does the new word sound like. Teachers rarely direct students to the acoustic properties of new vocabulary, names of people or places, or terminology; however, research has shown that active incorporation of acoustic, as well as semantic features of novel information facilitates later retrieval. For example, when discussing the concept of "hegemony" as a new vocabulary word in political science or social studies classes, teachers could ask, in addition to the semantic information, "What words do the word 'hegemony' remind you of?" (sample responses: "hedge," "money," "hide-your-money"). Such acoustic encoding can improve later recall of the word; mnemonic encoding, which actively relates the definition to the acoustic proxies, is even more effective in promoting retention.

Intelligence

Lower levels of intellectual functioning is a common reason for teachers to refer students for special education. However, all students with lower intelligence deficits may not require special education classes. With highly intensive, systematic instruction, many basic skills and deficits can be overcome. Meta-cognitive training, often undertaken in resource rooms, can also be helpful in preparing low-IQ students for mainstream classes.

In addition, there are a variety of teaching techniques available which improve the ability of students with intellectual deficits to perform in mainstream classes. These techniques can be derived from a substantial body of research literature which has accumulated over the past 60 years, regarding the relationship between learning and intelligence. Jensen (1989) has reviewed a wide range of previous experimental research, and offered some broad conclusions regarding the conditions of content and instruction that are likely to interact with deficits in general intellectual functioning. According to this analysis, students with lower levels of intellectual ability are likely to have difficulty learning when the content to be learned (a) requires conscious mental effort; (b) requires transfer from previous or related learning; (c) requires insight, involving "catching on," or "getting the idea;" (d) if the content is of moderate difficulty or complexity, necessitating simultaneous integration of information to enhance meaningfulness; (e) if the amount of time to learn is fixed for all students; (f) if the content is age-related; or (g) if performance is measured at an early stage of learning something new, rather that at a later stage when sufficient opportunity for practice has been allotted.

Using this analysis of learning and intelligence, recommendations for teaching students of low intellectual ability in the mainstream classroom are made:

1. Ensure that presented information is similarly meaningful to all learners. Research has repeatedly documented that students with lower levels of intellectual functioning have impoverished knowledge bases (MacMillan, 1982). This means that information that is meaningful to most learners may not be meaningful to students with intellectual deficits. When new content is being presented, teachers should be certain that relevant information is meaningful to all students, by questioning students about their understanding of this information. If some content does not appear as meaningful to some students, the meaningfulness of this content should be enhanced by providing concrete examples, analogies which link new content to the students' direct experience, or direct experience with the phenomena being studied. Enhancement of content meaningfulness consistently has been shown to improve student learning, including students with learning handicaps (Mastropieri & Scruggs, 1989).

2. Provide additional time to learn. Learning is correlated

with intelligence when the amount of time to learn is fixed for all students (Jensen, 1989). This means that lower functioning students can learn more like their mainstream peers if they are given additional time to learn the content. This can be achieved by (a) having the teacher, aide, or a peer monitor additional content coverage, perhaps when other class members are engaged in an independent "enrichment" activity; (b) arranging for the special education teachers to review the content outside of mainstream class time; or (c) providing parents with sufficient information to allow them to provide additional practice with the content at home. Research has suggested that increased engaged learning time is even more important for low-achieving than for high-achieving students (Berliner, 1984).

In all cases, additional time should be viewed as a positive opportunity to master the content, rather than punishment for being "slow." Any student employed as a tutor should regard the experience as a privilege, or should not be used. Finally, all personnel providing students with additional learning time should employ effective teaching practices, and be certain such opportunities are leading to increased learning. Students should not be supplied with additional time to study independently, unless it is certain that they possess sufficient basic skills, study skills, and self-discipline for this time to be productive.

3. Attend to developmental requirements of the content. Some content is age-related, to the extent that specific levels

of developmental functioning are associated with ability to understand the content. For example, mathematical abstractions, such as equivalence in the study of ratios or proportions, or abstractions in physical or chemical sciences, are more easily acquired by older than younger students. Students with tangibly lower levels of intellectual ability may function at a developmental levels associated with more younger students than with age peers (MacMillan, 1982). In cases in which content is decidedly age-related, it may be that developmentally delayed students will be more successful with this content at later ages. In classes in which such content dominates the curriculum, it may be wiser to integrate target students when they are a little older.

Although developmental constraints to learning represent a very real concern, many special educators are understandably wary of inappropriate applications of such thinking. If a student is judged to be "not ready" for certain instruction, it is important that such judgments are based upon solid evidence that the student in question is at present unable to learn. General judgments of readiness should not be made simply upon consideration of IQ scores. If an accurate judgment is made that a specific student is not developmentally "ready" for a specific content, it is also important to determine precisely which pre-skills the student lacks, begin to teach these skills and monitor progress toward mastery. Simply waiting for a student to grow older is never an optimal strategy.

4. Measure achievement at later, rather than earlier, stages of acquisition. Although formative evaluation should be provided throughout all stages of instruction (e.g., Fuchs, Fuchs, & Hamlett, 1989), students with lower intellectual functioning will fare better if all students are graded at later stages of learning a new content (cf. Jensen, 1989). Some students who fare quite poorly when content is first introduced will achieve much better after they have had time to become more familiar with the content. Such practices are unlikely to inhibit the performance of higher functioning students, but may do much to allow lower functioning students to succeed.

5. Use variables from the "effective teaching" literature. This literature, reviewed by Brophy and Good (1986), and Rosenshine and Stevens (1986), has also been described for special educators (Mastropieri & Scruggs, 1987). Teachers who use effective teaching variables teach directly to prespecified objectives, provide systematic teacher presentations which go directly, step-by-step, to the point of the content being taught, ask specific questions directly related to instructional objectives, provide sufficient guided and independent practice activities, and directly monitor student progress toward the meeting of instructional objectives. These procedures directly address potential problems arising from several of the abovementioned intelligence-and-learning variables. That is,

explicit, direct teaching practices require less conscious mental effort on the part of the learner, are less likely to require that students spontaneously transfer information learned in other settings, and are less likely to require that students must "figure out" what is to be learned, and how to learn it.

In addition to more general teacher effectiveness variables, explicit teaching of cognitive strategies necessary for efficient completion of academic tasks has been shown to be very helpful. Specific learning strategies for enhancing performance in a variety of academic areas have been described by Pressley et al. (1990).

Regular classroom teachers who carefully evaluate their own teaching may find that their questioning of students and task directions are often unnecessarily vague. With a little extra time spent in preparing questions and directions, these can be made much more explicit, and easier for students with intellectual deficits to understand.

6. Employ "discovery learning", "inquiry," or "constructivist" approaches judicially. Many regular educators embrace approaches which deliberately require conscious mental effort, transfer, and insight in learning, reasoning that information "discovered" by students is necessarily better understood than information directly communicated from teachers to students. In addition, it is argued, such approaches facilitate transfer, improve thinking skills, and more directly

involve students in the learning process (e.g., Julyan, 1989) than do standard textbook-lecture methods. While these approaches may be effective for some students, they may inhibit the learning of low-IQ students by placing excessive demands on learner insight (cf. Jensen, 1989). While constructivist or discovery approaches are often recommended for regular education students, there is little or no empirical research evidence supporting the use of such approaches with special education students (Mastropieri & Scruggs, 1987).

Teachers should carefully consider the purpose of their instruction. If knowledge of content is most important, the method by which content is acquired should be of secondary importance. That is, while some students could be encouraged to engage in "discovery" activities, other students, less capable of discovering school-relevant content on their own, could be provided with more direct approaches to acquire content knowledge. If, on the other hand, critical thinking skills are considered to be of overriding importance, teachers should ensure that all students are aware of the cognitive procedures necessary for critical thinking, and how to employ them. Direct teaching of thinking skills necessary for specific academic tasks could be helpful, in these cases. However, if teachers firmly believe that students should discover school content for themselves, _and_ they believe that students should also discover _how_ to discover school content, students with intellectual deficits will almost certainly fall behind.

Language Skills

The relationship between language skills and academic success has been well documented (e.g., de Villiers & de Villiers, 1978). Many students experience either receptive or expressive language problems, while some students exhibit difficulties in both. It is becoming increasingly recognized that many students with learning disabilities have concomitant language difficulties (e.g., Ceci & Baker, 1987), as do many students with mild mental retardation (MacMillan, 1982) and behavioral disorders (Scruggs & Mastropieri, 1984). It has also been seen that students with language problems may develop accompanying social behavior problems.

Students with language problems can be helped by use of the techniques described as follows:

1. Allow sufficient time for responding. If students have expressive language problems, they may simply require additional time to think up responses. Teachers should allow sufficient "wait time" (e.g., Rowe, 1974) after asking questions before eliciting response from students with expressive language problems. Additionally, some students may need to take their tests independently and have someone transcribe the responses.

2. Assist students with listening skills. Use consistent patterns for cuing students to listening. Cue students in to the important times for attending, and then check for understanding

by asking students to repeat the specific directions. Teachers can require the class to repeat assignments or important directions, or even write important points on the blackboard or the overhead projector. Teachers can also pair students together and frequently have members of each pair check to ensure comprehension is occurring.

3. Integrate language activities into regular instruction. Language and vocabulary need to be integrated within regular instruction. If, for example, a list of vocabulary words is given to students on a weekly basis, then teachers should encourage use of those words in speaking and in writing activities on a consistent basis, and not simply during the language lesson (M. Graves, 1986). Students with mild disabilities are less likely than their normally-achieving peers to independently make the transition from weekly list learning to enhanced skills in communication.

4. Support special services in language training. Depending on the precise nature of the language problems, special needs students may receive language training from special education teachers or speech therapists. In either case, the support of the regular classroom teacher can be of critical importance in (a) identifying the language problem and how it manifests itself in the classroom, (b) prompting and reinforcing in the regular classroom the application of skills newly learned in the special setting, and (c) facilitating the regular evaluation of progress

in language skills toward predetermined goals and objectives.

Social/Emotional Behavior

The relationship between learning and behavior has been well documented (e.g., Glover & Bruning, 1987); for this reason it is important to establish that observed problems in classroom behavior are not caused by learning problems. Many students who are experiencing learning difficulties would rather be perceived by their peers as a "behavior problem". They may also discover that, by exhibiting inappropriate behavior and being excluded from the classroom, they can avoid being perceived by their peers as "stupid." In such cases, students are deliberately disguising their learning problems, so particular attention must be given to determine the underlying nature of the problem. If it appears that academic skill (or attention, memory, or intellectual) deficits are at the heart of the behavior problem, instructional strategies appropriate for those deficits should be employed. Student behavior has been seen to increase dramatically as students become academically successful.

It also should be mentioned that behavior problems sometimes occur when students do not wish to be mainstreamed. Although educational "experts" and school personnel commonly identify mainstreaming as a very positive outcome, students may see the situation differently. Many special education students genuinely enjoy their special education classes, teachers, and peers, and are simply more comfortable and more secure in these environments. Many students enjoy the additional attention they receive in special education classes. Others would like to attend mainstream classes, but are frightened that they will not succeed or will not have any friends. These students also realize the strict behavioral requirements of regular education classes, and are well aware of what behaviors they can exhibit in order to be returned to special education classes. In such cases it is important to meet personally with students and explain the importance of attending the regular classroom. School personnel should listen carefully to students' concerns and do what they can to address them. It may be possible, for example, to integrate students over longer periods of time, or to help them become acquainted with some of the students in the class. Increased opportunities and privileges for students attending mainstream classes should also be specified. Above all, it should be remembered that the students have the power to "fail" in mainstream classed whenever they wish to, and their input into the process should be carefully considered.

For problems with withdrawal, aggression, disruptive behavior, social skills, one or more of the following strategies are likely to prove effective.

1. Direct appeal/Proximity. These strategies were described in the attention section, but can also be applied to overall social behavior. In the present case, direct appeal refers to speaking frankly and privately to students, precisely identifying

the problem and its classroom consequences, and directly asking for student help in improving the situation. Although a seemingly weak intervention, this strategy has been surprisingly effective in many cases. It can be especially effective in cases in which students do not consider themselves important members of the class, and do not think teachers are concerned about them. Proximity, also described above, is simply another way for teachers to show that they are directly interested in the improved classroom behavior of students.

2. Reinforce positive classroom behavior. Reinforcement of positive classroom behaviors can be accomplished in several ways (see Axelrod, 1983). A most effective way of doing this is first, to operationalize positive instances of target behaviors. To "operationalize" means to describe behaviors in ways that are easily observable. For instance to operationalize a problem with swearing, a positive instance is, "consistently uses appropriate classroom language." At regular time intervals (depending on the intensity of the behavior), teachers can give students "+" or a "0" if the appropriate behaviors were exhibited during the time intervals. If students earn a targeted proportion of "+"s by a pre-specified date, they are given rewards, such as desired objects or privileges. Again, if this appears likely to create problems with mainstream students, the reward could be in the form of a class privilege, in which all students could participate. Such class contingencies help give all students an

interest in the target student's positive behavior change.

As positive behavior is internalized, students should be encouraged to monitor their behavior independently, in ways similar to that described for self-recording of attention. The special education teacher should be able to assist in this type of training. Finally, provision of external rewards can be phased out, as students learn to appreciate the intrinsic rewards of good behavior.

3. Use peer mediation. Sometimes it is possible to pair target students with popular and responsible peers, who are assigned to help students monitor and control their own behavior (Kerr, Strain, & Ragland, 1982). Again, it should be mentioned that when peer mediation is used, it is important that peers regard the activity as a privilege or reward, rather than an undesirable obligation. Peers should be chosen who realize this and who have a sincere interest in helping other students. Assignment of peers to this task should be done in the presence of the peer and the target student. The behavior to be changed should be specified, as should the peer's role in affecting that change. In most cases, the role is simply to provide prompts, models, and positive alternatives for the inappropriate behavior. As with any intervention, progress toward a pre-specified objective should be monitored.

4. Utilize support personnel. If inappropriate classroom behaviors persist in spite overt efforts to improve them, it is likely that some unknown underlying problems are maintaining the behavior. It may also be that target students can not easily confide in classroom teachers. When this occurs, teachers should attempt to identify someone with whom the student can speak. Such individuals can include special education teachers, counselors, principals or assistant principals, although other school personnel or even older students could be helpful in providing students opportunities to discuss personal problems. However, it should be remembered that discussing problems is not a substitute for resolving problems. When difficulties have been identified, they should be tied to specific strategies for resolving them, as well as the accompanying behavior problem.

5. Teach social skills. Frequently, students know what behavior is expected of them, but deliberately choose to exhibit inappropriate behavior. Sometimes, however, students exhibit inappropriate behaviors simply because they have not received sufficient training in the exhibition of socially appropriate classroom behaviors. When this occurs, students should be taught how to behave appropriately. During the 1980's, social skills training received a good deal of attention in the special education literature (e.g., Gresham, 1982), and training materials were published (e.g., Jackson, Jackson, & Monroe, 1983). However, it seems unlikely that regular education teachers will have sufficient time or resources to teach social skills to those few students in need of such training. Rather,

social skills training is likely to be undertaken in special education classrooms. Although social skills training has been shown to be effective, it has also been seen that such skills rarely generalize to other settings unless the generalization is effectively programmed. This means that regular educators should directly cooperate with special education teachers in identifying social skill training needs, as well as effectively modeling, prompting, and reinforcing the social skills that have been learned in the special education setting (Mastropieri & Scruggs, 1984).

Affect/Motivation

Like classroom behavior, lack of motivation or display of inappropriate affect can be the consequence of academic deficits (Licht & Kistner, 1986), and teachers should first be certain that these problems are not in reality messages that students need academic help. If students appear to be functioning adequately academically, the following strategies may prove beneficial.

1. Create a positive, caring classroom atmosphere. Most teachers care deeply about the success and well-being of their students; however, many do not openly communicate these feelings, and some students may not appreciate the extent to which their teachers care about them. It is often insufficient to care about students -- it is also important to be certain that students are aware of their teachers' concern. It is important to have high

expectations, and to encourage students to work harder and continue to improve in school, but sometimes students interpret these attitudes as meaning that nothing they do will satisfy their teacher. The consequence is often less, rather than more, effort on the part of students. Teachers should continue to hold high standards, but they should also openly voice approval for successful steps made toward meeting these standards, and, more importantly, the exhibition of effort necessary to meet classroom expectations.

Although praise should not be used to reward trivial or effortless achievement, teachers should praise students whenever appropriate (see Mastropieri & Scruggs, 1987, for the most effective uses of praise). One way for teachers to determine how positive their classroom is, is to tape record portions of their own dialogue with students, and tally afterwards the proportion of positive vs. negative comments made to students. Many teachers who do this are surprised to find that they are mostly negative in their feedback. Ideally, however, a total proportion of 90% positive comments may not be too high, if effort and perseverance are being encouraged. When positive classroom comments are provided to students of low motivation or affect in appropriate circumstances, it is likely that positive increases in affect and effort will occur.

2. Use attribution training. Students with negative affect or poor motivation often have inappropriate attributions. In other words, when they succeed at classroom tasks, they are more likely to attribute it to "luck" than they are to their own efforts. However, when they fail at tasks, they may attribute it to negative self-characterizations, such as "stupid" or "lazy" (Licht & Kistner, 1986). Motivation is likely to increase when students correctly attribute academic success to effort, perseverance, and the use of task-appropriate academic strategies. Ability attributions, like "luck" attributions, are not helpful because they do address things the individual student cannot control. Appropriate attributions address things students are directly in control of, and consequently are likely to lead to increased effort (e.g., Borkowski, Weyhing, & Carr, 1988).

Teachers train attributions in the way they consequate success and failure on academic tasks. For example, when students succeed at a particular task, the degree of success should be attributed to the degree of effort, perseverance and appropriate strategy use by students. Student then learn that they are in control of their effort which is responsible for school success. On the other hand, when students do not succeed, correct attributions should also be made. For example, sometimes students simply do not expend sufficient effort, and should be provided with this feedback. Sometimes, however, the effort has been made, but students simply did not use task-appropriate academic strategies. These students should also receive this feedback. Over time, when students internalize such attributions, their sense of control, and consequently their level of motivation, is very likely to improve (Fulk & Mastropieri, in press).

3. _Establish goals for learning_. Sometimes motivation suffers because students come to regard school as an endless series of assignments and worksheets. To these students, completion of one difficult assignment is "rewarded" only by the provision of another difficult assignment. Consequently, students may begin to feel that there is no need to complete work quickly or efficiently; prompt task completion will simply bring on additional assignments. Teachers can help improve attitudes for school work by helping students set their own goals, both short-term and long-term, and help them monitor the progress they are making toward meeting those goals. Additionally, teachers should be sure that students feel rewarded for quick, efficient task completion, either with some "free time" or some more desired activity. Such teacher effort can provide dividends in the amount of effort expended by students.

4. _Consult support personnel when necessary_. In some cases, inappropriate affect can be an important signal that the student in question is in serious need of help. Inappropriate affect which does not respond to intervention may be a sign that the student is suffering from a more severe disorder, such as childhood depression or psychosis. Persistent display of irrational fears, inappropriately placed affect (either positive

or negative), bizarre speech, lethargy or depression may be signs that professional help should be sought. Since youth suicide has become an increasingly critical issue in public schools, it is important that teachers actively monitor affective problems in their students (Guetzloe, 1989). When severe affective or motivational problems arise, teachers should consult with the school psychologist or other support personnel in order to determine the most appropriate course of action.

Basic Skills

A major cause of mainstreaming failure is lack of basic skills, such as reading, writing, and math skills. If such deficits are mild, they are potentially remediable in regular elementary grade classrooms. If the deficits are more pronounced or appear at the secondary level, efforts to remediate them may be more appropriately made in special education classrooms, and appropriate mainstream strategies can be used to help cope with the deficits. Following are some recommended strategies:

1. Employ parents as tutors. In many cases, mildly handicapped students have acquired some basic skills knowledge, but need far more additional guided practice than mainstream teachers can provide. Parents can be a very positive resource in helping their children gain this additional learning time (Turnbull & Turnbull, 1982; Mehran & White, 1989).

If parents are used as tutors, it is very helpful that they be shown exactly what materials the student is working on, and be provided with specific guidance. For example, it would be helpful to indicate the specific materials the student is attempting to master, encourage the parents to tutor for pre-specified amounts of time (e.g., about 30 minutes per session), to keep the sessions positive and enthusiastic, to reward the student for effort and improvement, and to record progress on a daily basis for communication back to the teacher. For instance, if additional practice with reading is needed, parents could time the student's reading rate and number of errors for one minute timings after each tutoring session. When these data are presented to teachers, they will be able to determine whether the tutoring is meeting its purpose (see Becker, 1971, for additional information).

2. _Employ peer mediation_. Peers have been shown to be effective basic skills tutors of mildly handicapped students (e.g., Osguthorpe & Scruggs, 1986; Scruggs & Richter, 1986); in fact, mildly handicapped students have been seen to function effectively as tutors of other mildly handicapped students (Cook, Scruggs, Mastropieri, & Casto, 1985-1986; Scruggs & Osguthorpe, 1986), either in cross-age situations, or situations in which tutors and tutees were of the same age and ability. In all cases, tutored students have made substantial progress in the basic skills area being tutored -- it seems likely that if mainstream teachers can arrange for mildly handicapped students to be tutored, this will be helpful in enhancing basic skills

functioning. However, materials must be appropriate, carefully sequenced and structured, and the sessions should monitored, at least indirectly. As with all peer mediation, students acting as tutors should feel that what they are doing is a privilege, rather than an obligation, and an effort should be made to ensure that the right "chemistry" exists between tutoring dyads (see Jenkins & Jenkins, 1981, for additional information).

It has often been reported that tutors benefit more than tutees from the tutoring experience; however, in reality benefits to tutors are less certain and likely to be indirect, especially if the tutor has thoroughly mastered the content being tutored (Scruggs & Richter, 1985; Scruggs, Mastropieri, & Richter, 1985). Although it is true that tutors sometimes derive academic and social benefits, such as improved attitude for the content tutored, such benefits can not always be relied upon to justify the use of the tutors. Although improvement of "self-esteem" on the part of tutors has been widely reported, there is little if any empirical evidence that this actually occurs (Cook et al., 1985-1986). When using students as tutors, teachers should identify what benefits tutors are expected to obtain, and monitor whether such benefits are in fact occurring.

Cooperative learning strategies have been widely reported to enhance mainstreaming (Johnson & Johnson, 1980). These strategies also rely heavily upon the use of peers for support and for instruction. Typically, cooperative learning teams are selected by forming small groups from a heterogeneous mix of students. In this way each cooperative group is comprised of high, middle, and low ability students. Students within each group then assist one another with academic tasks. Various configurations have been reported in the literature, and results indicate positive growth on the part of all students who participate. Cooperative learning strategies can also be effectively employed for students whose presenting problems involve attention, language, or memory. However, in such cases, cooperating nonhandicapped students should be informed ahead of time of effective instructional strategies to help these students (see above).

3. Use the teacher effectiveness variables. The teacher effectiveness variables have been seen to produce marked improvement in achievement of regular and special education students. It seems reasonable then, to assume that if regular education teachers want to facilitate success in basic skill areas for special education students they will incorporate the teacher effectiveness variables into their instruction. For example, if teachers teach to clearly specified objectives, provide clear directions, guided and independent practice activities, and monitor student progress, progress in basic skill areas is likely to be enhanced. Additionally, it is critical for teachers to allocate instructional time wisely to ensure that as much time as possible is engaged in relevant activities. Finally, it may be possible to use active teaching procedures for

more of the class period, and independent reading and workbook activities for less of the period. Such teaching practices are likely to impact positively on the achievement of the class as a whole, while also relieving the handicapped student of the need to read, write, and study independently.

4. Teach cognitive strategies. It is becoming more and more apparent that special education students may approach academic tasks in less sophisticated ways than their typical peer counterparts (e.g., Mercer, 1987). These students can greatly benefit from cognitive strategy information that presents alternative ways for them to complete academic tasks. Some of the ideas mentioned in the self monitoring of behavior section can be applied to monitoring performance during academic tasks. Students can be instructed in specific reading strategies, such as self-questioning, self-monitoring, predicting, and question generating. They can also be taught specific math problem-solving strategies to facilitate their performance in mathematics. Similarly, recent research has demonstrated that students' written compositions improve with step-by-step instructions in cognitive strategies, including a self-monitoring component and a thorough task-analysis of each subtask involved. Many of these cognitive interventions have recently been tested empirically, and all results tend to indicate that students' performance in considerably increased under conditions of explicit cognitive strategy instructions. A recent text by

Pressley et al. (1990) summarizes the research and strategies in many of the basic skill areas.

5. De-emphasize textbook approaches where appropriate. In several content areas, such as science education, experts have called for hands-on, activity-oriented approaches to learning process skills, rather than textbook-based approaches which emphasize memorization (American Association for the Advancement of Science, 1989). By moving the learning environment away from textbooks, lectures, and abstractions, and toward interactive experiences with the phenomena being studied, teachers can more easily include students with basic skills deficits. Students who have difficulty succeeding in classes which require reading and listening may find activity-oriented approaches both easier to master as well as more enjoyable. Materials which can be used for this purpose in science education are described by the National Science Resources Center (1988).

In spite of the potential benefits of activities-oriented approaches to teaching, however, there are some potential problems with these approaches. As described above, some activity-oriented approaches to teaching may be so open-ended that mainstreamed special eduction students may lose sight of the purpose or procedures expected of them. Furthermore, unstructured "discovery" approaches may place inappropriate intellectual demands on the insight of low-IQ students, and may require prerequisite social skills that some mainstream students may lack. In order to avoid such problems, teachers should ensure that all students have necessary prerequisite skills for participating in such activities. Instructional activities should be developed which correspond with instructional objectives, and sufficient focus and structure to the activities should be provided so that special education students do not become "lost" during the process. As with all instructional activities, teachers should monitor student progress, to ensure that specific objectives are being met.

6. _Modify the demands of the class as necessary_. Many times students may be able to be very successful in content area classes if certain accommodations are made for them. This does not mean to imply that teachers should lower their standards, but does imply that some rules may be adjusted somewhat for special education students. For example, some students may require the assistance of someone during testing situations. This may involve having someone read the items on tests to students, or conversely, it may mean having someone transcribe the answers to test items for students. If the objectives are to determine the amount of content learned, then teachers should allow students opportunities to show what they know rather than penalize them for not being able to take the tests in the same formats as other students. Similarly, some students may require additional time to write out the responses to their tests, teachers could then schedule additional time for those students. Often, teachers can

arrange to have the assistance of special education teachers during testing, which would eliminate the need for putting special education students on the spot.

Teachers may also be able to arrange to have special education students have the use of computers and word processors during class assignments and during testing scenarios. Again, the use of a word processor may allow special education students opportunities to demonstrate more clearly what they know.

Teachers may be able to generate supplementary reading lists for students with low reading abilities. For example, textbooks that are written on lower readability levels, but cover similar content could be identified for special education students. These texts could help students with independent studying that might be impossible if they cannot decode the grade appropriate textbooks.

Finally, teachers may be able to work closely with special education teachers and parents in order to track the progress of special education students. This may be in the form of using curriculum-based measurement (Fuchs, Fuchs, & Hamlett, 1989), or in the form of behavioral contracting. In either case, clear goals can be specified with all parties involved and regular progress meetings can be held to determine whether anticipated goals are being met. If performance and progress is considered to be adequate, then instruction can proceed; however, if it is considered to be inadequate, then instructional decisions can be made so that performance and progress can improve. The specific instructional decisions can be made based upon the current level of instruction, and all involved parties can have a role in attempting to improve performance.

7. Intensify special education. Student with severe basic skills deficits will always have difficulty coping with regular class environments. Therefore, the first priority is for the student to acquire these skills as rapidly as possible. In direct, within-subject comparisons, it has been demonstrated that mildly handicapped students can acquire basic skills more rapidly in special education settings (Marston, 1988). In these settings, teacher ratios are more favorable, more time for learning basic skills is available, instruction is more intense and more specialized, and materials can be chosen for the students' individual needs. Mainstream teachers can help facilitate this process by working with special education teachers to identify the precise basic skills areas which most inhibit mainstreaming potential, and maximizing the amount of productive time which can be spent with special education teachers by cooperating on efficient scheduling.

When students have made sufficient gains on special instructional materials, they will need to make the transition to regular classroom materials. Teachers can help facilitate this process by sharing these materials with special education teachers, as well as criteria for acceptable performance on these materials. If mainstream teachers discuss which instructional strategies have been most effective with students, teachers can keep these strategies in mind when prompting students in regular classes. For example, many special education students who experience difficulty learning to read benefit from the careful sequencing and structure of intensive phonics instruction (Pressley et al., 1990). This may not be mainstream classroom teachers' method of choice, but they can learn to prompt students in the way in which mildly handicapped students have learned the best.

Study/Organizational Skills

Failures in mainstream classes can be attributed to a large extent on poor or inadequate study and organizational skills. Many special education students are notorious for having inadequate to nonexistent study and organizational skills. If students have weaknesses in these areas, they will probably experience difficulties with success in all or most of their academic classes. Deficits in study and organizational skills will also interact with deficits in basic skills, as well as most of the other areas identified, including attention, memory, intellectual, language, motivational, and social-behavioral. Efforts to teach study and organizational skills have occurred in special and regular education settings. With the advances in cognitive psychology research in strategic behaviors attributable to successful learning, many models for instructing students to become better "studiers" have appeared. If the deficits are extreme, then instruction should probably take place with the assistance of special education teachers. However, regular educators might find that the following suggestions would benefit not only their special education students, but also some of their regular education students.

1. Provide structure: Be explicit with all assignments. Teachers can provide needed structure for students by giving clear, explicit directions for all assignments. These directions can include models of appropriately completed assignments, timelines for anticipated completion, including due dates for drafts of papers, suggested dates for completion of various components of projects, and dates for extra help sessions for those interested. Finally, teachers can provide the criteria for acceptable performance on the project. This type of structure and explicitness can eliminate any ambiguities associated with assignments, and can assist special education students with understanding the expectations, and with timely and efficient task completion.

2. Teach general study techniques. It would be beneficial for teachers to provide some study sessions for students on how to succeed in the class. Suggestions could include: (a) the best ways to review and study the particular textbook, (b) the optimal ways to take class notes, (c) effective highlighting or outlining procedures, (d) ways of preparing for class tests, (e) optimal

ways of organizing class notebooks, (f) ways of keeping assignment books, and (g) how to be a prepared student for this class. Information on general study skills is provided by Carman and Adams (1977).

3. Teach specific test-taking skills. Special education students typically have poor test-taking skills (Scruggs & Mastropieri, 1988). However, research indicates that these skills can be trained and students' performance can increase. Since teachers typically administer tests of similar formats throughout the year, they could teach students how to prepare for those types of formats. For example, preparation for a multiple-choice exam would be quite different than preparation for an essay exam, and it would be beneficial for teachers to provide students with opportunities for studying and practicing on these various formats prior to having to perform on the actual tests (for additional information, see Scruggs & Mastropieri, in press b).

Summary

This paper has presented suggestions for optimizing mainstreaming of special education students. Characteristics of special education students have been listed, rather than specific categorical labels of these students. Then, suggestions for strategies for optimizing the mainstreaming success of these special education students are provided. It is believed that if teachers can begin to accommodate the needs of these special education students, they can increase the likelihood for success in mainstreamed settings.

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Author Note

Preparation of this manuscript was supported in part by a grant awarded to the authors from the U.S. Department of Education, Special Education Programs, #H023D00010.